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Vol. XIII August : 1970 No. 2

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पुस्तक संख्या
आगत पंजिका संख्या
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CONTENTS

Sr. No.	Article	Author's Name	Page
1.	Melville and the "Dark Hindoo Half of Nature"	K. R. Chandrashekharan	1
2.	ધ્વન્યાલોક (ઉદ્યોત ૧, ૨)નાં પ્રાકૃત ઉદાહરણોની પાઠચર્ચા	હરિવલ્લભ ભાયાણી	9
3.	સોલંકી યુગનું સાંસ્કારિક જીવન–એક દૃષ્ટિ	ભોગીલાલ જ. સાંડેસરા	18
4.	ભારતીય ઇતિહાસના કહેવાતા અંધકાર-યુગો (લેખાંક ત્રીજો)	જશુ બી. પટેલ	32
5.	Social Conflicts and Social Institutions in India	Dr. R. N. Saxena	52
6.	Teaching of Sociology in Regional Languages —A case study	Tara Patel	63
7.	Social Stratification and Non-violent Social Order–A case study of Village Community in Rajasthan	K. L. Sharma	71
8.	A study of Educational Choice and Socio-Economic Background of College students	S. C. Kanawala	81
9.	A study of the Dropouts in Post-graduate Education	L. R. Desai	88
10.	"Morphological studies in Jasminum Officinale Linn.	J. A. Inamdar, Asha J. Chohan and R. C. Patel	106
11.	Ontogeny of Axillary Buds in Trigonella Foenum-Graecum L.	J. J. Shah and K. Unnikrishnan	114
12.	Additions to the Flora of Gujarat; New Localities for the plants; Nomenclature charges	G. L. Shah	128
13.	Inhibition of the Corrosion of 63/37 Brass in Citric Acid	M. N. Desai and Y. C. Shah	139

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Sr. No.	Article	Author's Name	Page
14.	Inhibition of the Corrosion of 63/37 Brass in Nitric Acid	.. M. N. Desai and Y. C. Shah	.. 143
15.	Inhibition of the Corrosion of 63/37 Brass in Potassium Persulphate Solutions	.. M. N. Desai and Y. C. Shah	.. 146
16.	Methylamines as Corrosion Inhibitors for Aluminium-25 in Hydrolic Acid	.. M. N. Desai and Y. B. Desai	.. 152
17.	Adaptations for Food getting in Green Bee-Eater	.. U. M. Rawal	.. 164
18.	Ionic Antogonism in Zirconium Oxide Sols	.. I. M. Bhatt	.. 179
19.	Studies on Change of Conductivity During slow Coagulation	.. S. J. Doctor	.. 181
20.	Dissociation constants of Diethyldithiocarbamic Acid in Acetone-Water Mixtures	.. I. M. Bhatt and K. P. Soni	.. 183
21.	Agar Agar and Alginate Resources of India	.. J. J. Chinoy and B. S. Vaidya	.. 188
22.	Unsteady Laminar Flow of a Viscoelastic, Electroconducting Fluid under the Action of a Transverse Magnetic Field	.. K. N. Shah	.. 212
23.	On the Norm of an Operator	.. I. H. Sheth	.. 217
24.	Synthetic use of (+) Amyl Bromide from Fusel Oil	.. K. A. Thaker and I. G. Vasi	.. 218
25.	New Systematics : A Dynamic Approach to Classification of Plants	.. O. P. Saxena	.. 220
26.	Assessment of Micronutrient Availability in Soils of Gujarat, Part I	.. R. T. Dangarwala and B. V. Mehta	.. 233

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MELVILLE AND THE "DARK HINDOO HALF OF NATURE"

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I look, you look, he looks; we look, ye look, they look ..

And I, you, and he; and we, ye, and they, are all bats;

These words are spoken by Pip, the demented negro boy in the chapter, 'The Doubloon' in *Moby Dick*. The chapter is indisputably of great importance and contains clues which are likely to help the reader in understanding the central meaning of the book. Captain Ahab has in a dramatic manner nailed the gold coin of Ecuador to the main mast as a symbol of his dedication to his dire purpose. In the chapter, 'The Doubloon', some of the main characters of the novel are made to appear in succession before the mast and to give their own interpretations of the significance of the coin. Captain Ahab is the first to present himself and after giving his egoistic interpretation of the figures engraved on the doubloon he remarks :

> . . . . . and this round gold is but the image of the rounder globe, which, like a magician's glass, to each and every man in turn but mirors back his own mysterious self. Great pains, small gains for those who ask the world to solve them; it can not solve itself. (*Moby Dick :* Chapter XCIX – page 428)

What Ahab says of the doubloon is applicable to the book itself. It is now generally accepted that the story and the characters have some moral significance and that the whole is meant to be a symbol. Several books have been written about it and numerous interpretations of its meaning have been offered, but there is no finality about any of these interpretations. The book, in the words of Captain Ahab, "like a magician's glass, to each and every man in turn but mirrors back his own mysterious self". A cynic might even echo the words of Pip and affirm : "I look, you look, he looks; we look, ye lock, they look . . . . And I, you, and he; and we, ye, and they, are all bats;" In humbler moments we may concede that all the relevant things which may be said about the book have been already said by other people. Henry A. Murray aptly takes this view

Note : The edition of *Moby Dick* used is the Modern Library edition, Random House, New York, 1950.

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when he remarks : " Since one or another of these authors has deftly said what I clumsily thought, my prejudices are strongly in favour of their conclusions, and I am whole-hearted in applauding them .. despite their having left me with nothing fresh to say" ("In Nomine Diaboli" in *Melville : a collection of Critical essays*, ed : Richard Chase, p. 66).

Luckily it is still possible to find something fresh to say about a great and profound book like *Moby Dick.* The problems posed by the novelist are not easy of solution and, as he very often suggests, the points of view are numerous. There is, however, an invitation or challenge in the book to those of us who value foreign literatures and at the same time have some knowledge of our own religions and cultural heritage. The Hindu Gods, Brahma, Vishnu and Siva are explicitly mentioned and Vishnu is described with considerable levity as one of the earliest whalemen. The most challenging statement in the book from the Hindu point of view occurs in the chapter, 'The Dying Whale'. Ahab has been watching a whale dying and he has observed that the whale has its head turned towards the sun at the moment of its expiry, but that immediately after death the head turns away in some other direction. This strange spectacle sets the captain thinking, and he soliloquizes as follows :

> Oh, thou dark Hindoo half of nature, who of drowned bones has builded thy separate throne somewhere in the heart of these unverdured seas; thou art an infidel, thou queen, and too truly speakest to me in the wide-slaughtering Typhoon, and the hushed burial of its calm. Nor has this thy whale sunwards turned his dying head, and then gone round again, without a lesson to me.
>
> Oh, trebly hooped and welded hip of power ! Oh, high aspiring, rainbowed jet ! — that one strivest, this one jettest all in vain ! In vain, oh whale, dost thou seek intercedings with yon all-quickening sun, that only calls forth life, but gives it not again. Yet dost thou darker half, rock me with a prouder, if a darker faith. All thy unnamable imminglings float beneath me here; I am buoyed by breaths of once living things, exhaled as air, but water now (*Moby Dick*, Chapter CXVI, p. 490).

The above soliloquy is a faithful expression of the monomaniac captain's attitude to life. He admittedly sees only the dark side of the universe. Evil to him is an ever-present reality. In his mind the white whale is the symbol of this harsh reality and his sole aim in life is to destroy it if he can or to perish in the attempt.

> All that most maddens and torments; all that stirs up the lees of things; all truth with malice in it; all that cracks the sinews and cakes the brain; all the subtle demonisms of life and thought; all evil, to crazy Ahab, were

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visibly personified, and made practically assailable in Moby Dick. He piled upon the whale's white hump the sum of all the general rage and hate felt by his whole race from Adam down; and then, as if his chest had been a mortar, he burst his hot heart's shell upon it (*Moby Dick*, Chapter XLI - p. 183).

The immediate question for us is not how far Melville approves of Ahab's attitude to Moby Dick or how far he admires him for his strength and singleness of purpose. We have first to find out why he describes the darker side of the world as the 'dark Hindoo half of nature' and then to examine whether he is justified in his assessment of the Hindu view of the world. A great masterpiece like *Moby Dick* is read and sometimes uncritically read, by people all over the world. Statements made in such a book about a remote land, its people and its religion are very likely to be accepted as the truth by the layman. I have had the experience of being interrogated by Europeans and Americans about the central teachings of Hinduism and I have occasionally experienced difficulty in convincing them that this religion is something more than the worship of the cow. When an erroneous or misleading statement is contained in a widely-read book, it behoves the disinterested student to correct it so that at least in academic circles there may be correct understanding.

Melville shows some knowledge of the story of the incarnation of Vishnu as a fish in the chapter, 'The Honour and Glory of Whaling'. Here is his summary of the story, obviously written in a flippant tone :

> When Brahma, or the God of Gods, saith the Shaster, resolved to recreate the world after one of its periodical dissolutions, he gave birth to Vishnoo to preside over the work; but the Vedas, or mystical books, whose perusal would seem to have been indispensable to Vishnoo before beginning the creation, and which therefore must have contained something in the shape of practical hints to young architects, these Vedas were lying at the bottom of the waters; so Vishnoo became incarnate in a whale, and sounding down in him to the uttermost depth, rescued the sacred volumes. Was not this Vishnoo a whaleman then ? even as a man who rides a horse is called a horse man ? (*Moby Dick* p. 362–63)

We have a clue to Melville's notion of the Hindu religion in the chapter, 'Midnight, Forecastle'. In this chapter all the harpooners and sailors on board make their appearance. Each of the sailors says something which is supposed to be characteristic of his race or nationality. In this parade of nations India is represented by the Lascar sailor who speaks these words when the sky is darkening and the wind is rising :

> By Brahma ! boys, it'll be douse sail soon. The sky-born, high-tide Ganges turned to wind ! Thou showest the black brow, Seeva ! (*Moby Dick*, p. 172)

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The Indian sailor associates the storm and the darkness with Siva, the God of destruction. Melville, therefore, knew that in the Trinity of the Hindus Siva represented the forces of annihilation. With his imperfect knowledge of Hindu philosophy he must have equated the Hindu scheme of the Universe with the Manichaean creed with its clear division of good and evil. Ahab's tragic error in the novel is to isolate and dwell on the evil side of the universe and thus fail to see the true relationship between evil and good. The rigid distinction he makes between these two forces is identical with the distinction which, according to Melville's mistaken notion, the Hindus make. My analysis of Melville's mistake is supported by H. Bruce Franklin in his book, *The Wake of the Gods* in which the author surveys the numerous Indian myths that Melville probably was acquainted with. Regarding the myths concerning Vishnu and Siva, Franklin writes : "Most of the mythologists read by Melville tended to conceive of the periodic avatars of these conflicting principles in Manichean terms, comparing them most often to Ormuzd and Ahriman of the Zoroastrians and Osiris and Typhon of the Egyptians ".

Moby Dick presents among other things two views of the world, one represented by Ahab and the other, which may be assumed to be the author's own, expressed mainly through Ishmael. Ahab's universe is one of unrelieved darkness in which inscrutable malice dominates. Human life to him is a struggle against unseen, malicious forces. His interpretation of the figures on the doubloon clearly brings out his philosophy :

> From storm to storm ! So be it then. Born in throes, 'tis fit that man should live in pains and die in pangs. So be it then ! (*Moby Dick*, p. 428)

Indeed, to Ahab, Siva shows his dark brow. What he sees before him is the 'dark Hindoo half of nature' unrelieved by light or joy. Melville does not approve of this attitude and therefore suggests that the punishment that is meted to him in the end is deserved. "I have written a wicked book, and feel spotless as the lamb", he wrote in a letter to Hawthorne. The wickedness lay in sympathetically depicting Ahab's blasphemous conduct in pitting his puny self against God's scheme of things and almost suggesting that there was something heroic in such conduct. There is a family likeness between Ahab and Prometheus and Lucifer. To the extent Melville represented Ahab's rebellion as heroic he was guilty of writing 'a wicked book'. At the same time the author felt spotless as the lamb because he gave the hero the terrible punishment his conduct called for and vicariously took part in that punishment. Ahab's sin was to accept the Manichaean doctrine — a doctrine which Melville identified with not only Hindu thought but also Zoroastrianism. Fedallah the Parsee is Ahab's evil genius. The fault of Fedallah again is the fault of dichotomizing the world and seeing only one side of it — the evil side. Melville thus sees no difference

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between the Hindu view and the Zoroastrian view of life. Both are to him imperfect, defective and ruinous.

Melville's own view of life seems to be represented in the novel by Ishmael, the sole survivor of the catastrophe. In the course of his interpretation of the whiteness of the whale, Ishmael remarks : "Though in many of its aspects this visible world seems formed in love, the invisible spheres were formed in fright". Here there is recognition of the coexistence of good and evil although there is no attempt to reconcile and harmonize them. As Newton Arvin has pointed out, Melville's final choice would be for the 'double vision' suggested by the picture on the doubloon — that of the sun entering the Zodiac at the sign of the Libra or the Scales symbolizing balance, impartiality and equanimity.

Throughout *Moby Dick* there are symbols and explicit descriptions which show that Melville was conscious of the essential unity underlying the phenomenal duality of the universe. The whale in one of its aspects is life-giving and beneficent. It provides man with food, with oil and with the fragrant ambergris. There is also another aspect largely symbolized by Moby Dick. It is an embodiment of brute strength and malice against which man's strength is of no avail. Ahab's quest is futile because the odds are heavily against man and malicious because it is the result of a morally indefensible assessment of reality. It is significant that during the third day of the chase, it is not the whale that pursues him although it has been wounded. Starbuck warningly tells him : "See ! Moby Dick seeks thee not. It is thou, thou, that madly seekest him !" The evil that Ahab associates with the whale is evil projected by his own diseased will and imagination.

Melville, although he describes the honour and the glory of whaling as a profession, is able to see the other side of the picture. He realizes that the whale as a creature of God has as much right to live as any other creature. He sees the irony of people assembling for worship in a church which is lighted by candles obtained by the slaughter of the innocent whale and the preacher expatiating on charity and kindness to all beings. He is also conscious of the suffering inflicted on the whale by its hunter as the following tender and poetic description of a dying whale will bear out :

> It was a terrific, most pitiable, and maddening sight. The whale was now going head out, and sending his spout before him in a continual tormented jet; while his own poor fin beat his side in an agony of fright. Now to this hand, now to that, he yawed in his faltering flight, and still at every billow that he broke, he spasmodically sank in the sea, or sideways rolled towards the sky his one beating fin. So have I seen a bird with clipped wing, making affrighted broken circles in the air, vainly striving to escape the piratical hawks. But the bird has a voice, and with plaintive cries will make known her fear; but the fear of this vast dumb brute of the sea,

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> was chained up and enchanted in him; he had no voice, save that choking respiration through his spiracle, and this made the sight of him unspeakably pitiable; (*Moby Dick*, Chapter LXXXI — p. 353).

One of the important symbols introduced by Melville is ambergris, 'an essence found in the inglorious bowels of a sick whale' (Chapter XCII - 407). Melville carefully points out to the reader the significance of the symbol when he writes :

> Now that the incorruption of this most fragrant ambergris should be found in the heart of such decay; is this nothing ? Bethink thee of that saying of St. Paul in Corinthians, about corruption and incorruption; how that we are sown in dishonor, but raised in glory (p. 407–408).

Another powerful symbol is Queequeg's coffin which is converted into a life-buoy and which at the end of the story providentially saves the life of Ishmael. Melville's mind seems to be preoccupied with the real oneness of things which appear to be polar opposites. As if to strike home this lesson of opposites merging into one another he introduces the extraordinary episode of a sky-hawk getting caught between the hammer wielded by Tashtego and the mainmast as the Pequod is rapidly sinking and thereby going down with the ship which, like Satan, would not sink to hell till she had dragged a living part of heaven along with her, and helmeted herself with it ". (*Moby Dick*, p. 565)

The sea itself is one of the most eloquent symbols used by Melville. Lovely, majestic and life-supporting, it has 'a tiger-heart panting within'. It has its 'subtle demonism', its 'vulturism'. Its waters wash the bones of countless beings, human and non-human. It is made up of the 'breaths of once living things, exhaled as air, but water now ! (Chapter CXVI - p. 490)

Melville's major preoccupation in the novel is with the problem of evil. The book is intended to be a corrective to the literature produced by the romantics, with its easy optimism and its avoidance of the ugliness and the pain which are also facets of reality. The remarkable thing, however, is that in spite of his readiness to portray what appears to be evil, be insists that it would be wrong and fatal to isolate it, to exaggerate it and to allow it to become such an obsession that it blinds us to the other side of the picture. Life, as Melville sees it is a web woven out of multi-coloured yarn. Against the vulturism and the demonism which lurk in the waters of the sea of life Melville places many qualities and virtues which ennoble and sanctify it. Tolerance and charity have primary place among these virtues. The tender relationship which is built up between the Christian Ishmael and pagan Queequeg, and their being tied to each other literally and figuratively with the monkey-rope are symbolic of the human solidarity which Melville believes to be among God's greatest gifts to man. There is a highly poetic description of the bond of love which binds man to man and gives sweetness to life in the chapter, 'A Squeeze of the Hand'. Ishmael

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is sitting before a tub full of spermaceti in which a part of the sperm has cooled and crystallized into lumps. He is engaged in squeezing back these lumps into liquid form. He explains :

> Squeeze ! Squeeze ! Squeeze ! all the morning long, I squeezed that sperm till I myself almost melted into it; I squeezed that sperm till a strange sort of insanity came over me; and I found myself unwittingly squeezing my colaborers' hands in it, mistaking their hands for the gentle globules. Such an abounding, affectionate, friendly, loving feeling did this avocation beget; that at last I was continually squeezing their hands, and looking up into their eyes sentimentally; as much as to say, — Oh ! my dear fellow beings, why should we longer cherish any social acerbities, or know the slightest ill-humor or envy. Come; let us squeeze hands all round; nay, let us squeeze ourselves into each other; let us squeeze ourselves universally into the very milk and sperm of kindness. (*Moby Dick*, p. 415)

Melvilles' vision of life, therefore, is very different from that of Ahab. He is able to see both the beauty and the sadness of life. He shows his awareness of the duality which confronts us wherever we turn. He is not vain enough to pretend to be able to offer a solution. All that he does is to give artistic form to a unified view of life which ignores neither aspect of the truth and enables man to accept life for what it is and thus find some measure of serenity and joy instead of trying to change what he is powerless to change.

The questions now remain — why did Melville describe the evil side of life as the ' dark Hindoo half of nature ' and how far was he right in thus describing it ? On the face of it one may take the description to imply that Hindus are pessimists and the nature that they see is only the dark half of nature. This does not seem to be Melville's meaning. I have already mentioned that what Melville refers to here is the element of Manichaeanism in Hindu thought which sees the universe as composed of two halves — not complementary but entirely opposed to each other. The Lascar sailor's reference to Siva in connection with storm and darkness bears out this interpretation. The Hindu world as imagined by Melville is a world consisting of a bright half presided over by Vishnu and a dark half over which Siva rules. It is obvious to anyone acquainted with Hindu philosophy that this is by no means a correct interpretation. More than anything Hinduism emphasizes the unity which exists in diversity. The Upanishads and the *Bhagavad Gita* repeatedly assert that there is nothing in the world which does not proceed from God. Differences are apparent and illusory and not real. This truth is brought out for instance in the following stanza from the *Bhagavad Gita :*

> I am heat; I send forth and withhold the rain; I am immortality and death;
> I am good and also evil, Oh, Arjuna ! (Chapter IX, verse 19)

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Melville could have obtained a correct explanation of the Hindu view which closely resembles his own conception of the 'double vision' from any of the numerous translations of our Scriptures that were available before the publication of *Moby Dick*. One of the most poetic and reliable statements of the Hindu position in the English language is Emerson's poem, *Brahma :*

Far or forgot to me is near;
Shadow and sunlight are the same;
The vanished gods to me appear;
And one to me are shame and fame.

Unfortunately *Brahma* was published only in 1857, six years after the publication of *Moby Dick*. Emerson and Thoreau had access to and made ample use of reliable source-books of Hindu philosophy such as Rammohan Roy's translation of the Principal Upanishads, Charles Wilkins' translation of the *Bhagavad Gita*, H. H. Wilson's translation of the *Vishnu Purana* and so on. Unfortunately, as Dorothee M. Finkelstein points out in her scholarly book, *Melville's Orienda*, Melville derived his information about Hinduism from the book, *Indian Antiquities*, written by a British missionary, Thomas Maurice. This pious missionary naturally wrote with scorn and contempt about the Hindu religion and religious practices. One of his peculiar tendencies is to find the phallic symbol everywhere in India. Melville's wrong notions about Hinduism, therefore, are derived from Maurice. It pains me to have to mention that even Miss Finkelstein who has made a careful study of Melville's Oriental sources fares no better than Melville when she writes about Hinduism. *Melville's Orienda* contains three references to Hindus or Hinduism — on pages 13, 156 and 163. Page 13 only mentions the word 'Hinduism' and page 163 the word 'Hindus'. On page 156 there is a reference to the first incarnation of Vishnu which should amuse all Hindus. It reads : "His description of the fishlike incarnation *of the Hindu goddess Vishnu*, "the Matse Avatar", has been known to stem from Thomas Maurice's *Indian Antiquities*". The index to the same book also has this entry : *Vishnu* (*Hindu goddess*).

Moby Dick as a work of art perhaps has not suffered as a result of Melville's misunderstanding of the Hindu view of life. The main point is that the novelist goes out of the way to enrich the novel by giving it many dimensions. He has ransacked whole libraries in order to collect information on different subjects. It may be wishful thinking, but one cannot help feeling that if he had read authentic source-books on Hinduism, as his great contemporaries, Emerson and Thoreau did, he would have found in Hindu thought ample confirmation of his own philosophical position. At any rate he would not have made glib references to Vishnu as the first whaleman, to Siva's dark brow and to the 'dark Hindoo half of Nature'.

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ધ્વન્યાલોક(ઉદ્યોત ૧, ૨)નાં પ્રાકૃત ઉદાહરણોની પાઠચર્ચા

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ભાષા-સાહિત્ય ભવન
અમદાવાદ-૯

ઘણાખરા અલંકારગ્રંથોમાંનાં પ્રાકૃત ઉદાહરણોનો પાઠ તેમનાં પ્રચલિત સંપાદનોમાં વધતોઓછો ભ્રષ્ટ સ્વરૂપમાં અપાયેલો હોય છે[1], અને 'ધ્વન્યાલોક' (તથા 'લોચન') પણ આમાં અપવાદ નથી. કાશી સંસ્કૃત સિરીઝમાં પ્રકાશિત 'બાલપ્રિયા' ટીકાવાળી શ્રી. રામષારકની આવૃત્તિ (૧૯૪૦), રામસાગર ત્રિપાઠીની તારાવતી વ્યાખ્યાવાળી આવૃત્તિ (૧૯૬૩), વિષ્ણુપદ ભટ્ટાચાર્યની આવૃત્તિ, ચૌખંબાવાળી જગન્નાથ પાઠકની આવૃત્તિ (૧૯૬૫), તેમ જ ડોલરરાય માંકડનું સંપાદન (૧૯૬૯)—એ બધામાં પ્રાકૃત ઉદાહરણો ઘણી કરુણ દશામાં જોવા મળે છે.

'લોચન'માં એ ઉદાહરણોની સંસ્કૃત છાયા આપેલી હોવાથી અર્થ સમજવા પૂરતું કામ નભી જાય છે ખરું, પણ સ્થૂળ રીતે જ. થોડીક ખણખોદ કરવા જતાં તરત જ કેટલીક મુશ્કેલીઓ ઊભી થાય છે.

પ્રાકૃત ગાથાના પાઠની અને અભિનવગુપ્તની છાયાની વચ્ચે વિસંગતિ હોય એવાં સ્થાન ઓછાં નથી. અને એ ઉપરથી પ્રતીત થાય છે કે અભિનવગુપ્ત પાસેનો પાઠ વૃત્તિમાંની ગાથાઓના સંપાદિત પાઠથી કેટલીક બાબતમાં જુદો હોવો જોઈએ.

અહીં ધ્વન્યાલોકના પહેલા બે ઉદ્યોતમાંની પ્રાકૃત ગાથાઓની પાઠશુદ્ધિ ચર્ચી છે. આમાં 'કાવ્યાનુશાસન' અને 'ગાથાસપ્તશતી'માં (કે કવચિત્ અન્યત્ર) મળતા પાઠોને પણ લક્ષમાં લીધા છે.

ઉપયોગમાં લીધેલા ગ્રંથોનાં નામસંક્ષેપ, આવૃત્તિ વગેરે નીચે પ્રમાણે છે:

કાવ્યા૦=પરીખ અને કુલકર્ણી સંપાદિત હેમચંદ્રકૃત 'કાવ્યાનુશાસન' (બીજી આવૃત્તિ, ૧૯૬૪).

ગા૦સ૦=હાલકૃત 'ગાથાસપ્તશતી' (નિર્ણયસાગરની ૧૯૩૩ની કાવ્યમાલા-આવૃત્તિ)

દે૦ના૦=હેમચંદ્રકૃત 'દેશીનામમાલા'.

ધ્વ૦=ધ્વન્યાલોક.

પિશેલ=પિશેલના પ્રાકૃત વ્યાકરણનો સુભદ્ર ઝાકૃત અંગ્રેજી અનુવાદ—Comparative Grammar of the Prākrit Languages (બીજી આવૃત્તિ, ૧૯૬૫).

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[1] પરીખ અને કુલકર્ણીના હેમચંદ્રકૃત 'કાવ્યાનુશાસન'ના સંપાદનનો એક પ્રશસ્ય અપવાદ તરીકે ઉલ્લેખ કરવો જોઈએ.

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માં૦=ડોલરરાય માંકડ સંપાદિત અને અનુવાદિત 'ધ્વન્યાલોક' (અમદાવાદ, ૧૯૬૯).
સિ૦ હે૦='સિદ્ધહેમ શબ્દાનુશાસન'
વેબર=વેબરસંપાદિત Saptas'atakam des Hāla (મૂળ ૧૮૮૧; પુનર્મુદ્રિત ૧૯૬૬)

ઉદ્યોત પહેલો

૧. भम धम्मिअ वीसत्थेा से सुणओ अज्ज मारिओ देण ।
गोलाणइकच्छकुडङ्गवासिणा दरिअसीहेण ॥

(ધ્વ૦ ૧/૪ નીચે; માં૦, પૃ. ૫, ૧૧૮, ૨૧૬, ૩૪૪; ગા૦સ૦, ૨/૭૫; કાવ્યા૦, પૃ. ૪૭, ૫૧૦.)

दे એ સ્વરૂપ વિશિષ્ટ પરિસ્થિતિમાં વપરાય છે, અને देण રૂપ અત્યંત વિરલ અને મહારાષ્ટ્રીમાં અજાણ્યું છે. (પિશેલ, §૪૨૫, §૨૭૫). વ્યાપક અને માન્ય તો त- અંગ ઉપરથી तेण એવું તૃતીયા એકવચનનું રૂપ છે. એટલે અહીં देणને સ્થાને तेण જોઈએ. વેબર વગેરેમાં तेण જ છે. 'કાવ્યાનુશાસન'માં પણ.

વેબરે वीसद्धो, सुणहो અને गोलाअडविअडकुडुंग० (=गोदा-तट-विकट-निकुञ्ज०) એવા પાઠ સ્વીકારેલા છે. दरिअसीहेण 'સિદ્ધહેમ' (૮-૧-૧૪૪, ૮-૨-૯૬)માં ઉદાહરણ તરીકે આપેલ છે, અને કાવ્યા૦માં विस्रब्धो भ्रम એવો સંસ્કૃત અનુવાદ આપ્યો છે.

૨. अत्ता एत्थ णिमज्जइ एत्थ अहं दिअसअं पलोएहि ।
मा पहिअ रत्तिअन्धअ सेज्जाए महँण मज्जिहिसि ॥

(ધ્વ૦ ૧/૪ નીચે; માં૦, પૃ. ૫, ૧૧૮, ૨૧૬, ૩૪૪; ગા૦સ૦, ૭/૬૭; વેબર, ૬૬૯; કાવ્યા૦, પૃ. ૫૩, ૫૦૫; અનેક અલંકાર ગ્રંથોમાં ઉદ્ધૃત; પિશેલ, §૧૧૮ નીચે)

પ્રથમ તો ગાથાનો અંતભાગ ભ્રષ્ટ છે, તે સુધારી લઈએ. महँण मज्जिहिसिને સ્થાને मह णिमज्जिहिसि જોઈએ.

બીજો પ્રશ્ન પૂર્વ ભાગમાં જે णिमज्जइ અને ઉત્તર ભાગમાં णिमज्जिहिसि છે તેના સ્વરૂપ અને અર્થને લગતો છે.

ગા૦સ૦ અને વેબરમાં णिमज्ज° છે, પણ કાવ્યા૦માં, વેબરે નોંધેલાં પાઠાંતરોમાં અને પિશેલે નોંધ્યા પ્રમાણે કેટલાક અલંકારગ્રંથોમાં णुमज्ज° છે. णुमज्ज°વાળું રૂપ જ પિશેલે સમર્થિત કર્યું છે.

અહીં णुमज्जના અર્થ અને વ્યુત્પત્તિની બાબતમાં મતભેદ છે.

કાવ્યા૦માં હેમચંદ્રે नुमज्जिहसि (પાઠાંતર नुमज्जिहिसि)નો અર્થ निषत्स्यसि કર્યો છે, પણ 'વિવેક'માં शयिष्ठाः અને णुमज्जइનો शेते એવો અર્થ કર્યો છે. સિ૦હે૦ ૮-૧-૧૭૪માં અને निषण्णનો नुमण्ण આદેશ થતો હોવાનું કહ્યું છે અને ૮-૪-૧૨૩માં निषद्‌નો णुमज्ज આદેશ આપીને 'अत्ता एत्थ णुमज्जइ' એટલો આપણી ગાથાનો અંશ ઉદાહૃત પણ કર્યો છે.

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પણ સામે પક્ષે માર્કંડેય 'પ્રાકૃત સર્વસ્વ' ૭/૩૮માં **णुमज्जइ**નો અર્થ **शेते** આપે છે, અને હેમચંદ્રે પોતે દે૦ના૦ ૪/૨૫માં **णुवण्णो=सुप्तः** એમ આપ્યું છે. પિશેલ અર્થને ધ્યાનમાં લઈને **णुमज्जइ**ને વૈદિક **निपद्यते** 'સૂએ છે'માંથી થયેલું માને છે. વધુ સંભવ એ છે કે **उम्मज्जइ**ની અસર નીચે **णिमज्जइ**નું **णुमज्जइ** થયેલું છે, અને મૂળનો અર્થ પરિવર્તિત થઈને સૂવાનો અર્થ ઉદ્ભવ્યો છે. **णुमण्ण** પણ સાદૃશ્યપ્રભાવે **निमग्न**નું જ રૂપાંતર છે.

બંને પંક્તિમાં ગાથા૦નો પાઠ જુદો છે. તે આ પ્રમાણે છે:

एत्थ णिमज्जइ अत्ता एत्थ अहं एत्थ परिअणो सअलो ।
पंथिअ रत्तीअंधअ मा मह सअणे णिमज्जिहिसि ॥

કાવ્યા૦ના સંપાદકોએ **नु मज्जइ** અને **नु मज्जिहसि** એમ नुને જુદો ઘટાવ્યો છે તે ભૂલ ગ્રંથાંતે આપેલી સંસ્કૃત છાયામાં સુધારી લીધી છે. કાવ્યા૦વાળા પાઠમાં **पलोएहिं**ને બદલે **पुलोएसु** રૂપ છે તે વધુ યોગ્ય છે. વળી **णुमज्जिहांसि**ને બદલે **णुमज्जिहिसि** રૂપ વધુ પસંદ કરવા યોગ્ય છે.

આ ચર્ચા અનુસાર ગાથાનો પાઠ નીચે પ્રમાણે જોઈએ:

अत्ता एत्थ णुमज्जइ एत्थ अहं दिअसअं पुलोएसु ।
मा पहिअ रत्तिअंधअ सेज्जाए महं णुमज्जिहिसि ॥

અર્થ: 'બાઈજી અહીં સૂએ છે, અહીં હું—દિવસે (જ) જોઈ લે: હે પથિક, રતાંધળા, તું રખે મારી શય્યામાં સૂઈ પડતો'.

3. वच्च मह **व्विअ एक्केइ** होन्तु णीसासरोइअव्वाइं ।
मा **तुज्ज** वि **तीअ** विणा दक्खिण्णहअस्स जाअन्तु ॥
(ધ્વ૦ ૧/૪ નીચે; માં૦, પૃ. ૫, ૧૧૮, ૨૧૬, ૩૪૪; વેબર, ૯૪૪;
કાવ્યા૦, પૃ. ૫૬, ૫૧૧).

व्विअને બદલે **च्चिअ**, **एक्केइ**ને બદલે **एक्काए**, **तुज्ज**ને બદલે **तुज्झ** અને **तीअ**ને બદલે **तीए** જોઈએ.

૪. दे आ पसिअ णिवत्तसु मुहससिजोण्हाविलुत्ततमणिवहे ।
अहिसारिआणँ विग्घं **करोसि अण्णाणं** वि हआसे ॥
(ધ્વ૦ ૧/૪ નીચે; માં૦પૃ. ૫, ૧૧૮, ૨૧૬–૨૧૭, ૩૪૪; વેબર, ૯૬૮;
કાવ્યા૦, પૃ. ૫૫).

अहिसारिआण, करेसि અને **अण्णाण** એમ પાઠ જોઈએ.

૫. कस्स ष ण होइ रोसो दट्ठूण पिआए सव्वणं **अहरम्** ।
सभमरउपमग्घाइणि **वारिअ वामे** सहसु **पहूणिम्** ॥
(ધ્વ૦ ૧/૪ નીચે; માં૦, પૃ. ૫, ૧૧૮, ૨૧૭, ૩૪૪; વેબર, ૮૮૬;
કાવ્યા૦, પૃ. ૫૭.)

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अहरं, °पउम°, वारिअवामे અને एण्हिं એમ જોઈએ.

'°मग्घाइरिं' પાઠ વેબરમાં, કાવ્યા૦માં છે. आघ्राणशीले એ અર્થ માટે તે વધુ અનુકૂળ છે.

૬. चुम्विज्जइ सअहुत्तं अवरुन्धिज्जइ सहस्सहुत्तम्मि ।
विरमिअ पुणो रमिज्जइ पियो जणो णत्थि पुनरुत्तम् ॥

(ધ્વ૦ ૧/૧૭ નીચે; માં૦, પૃ. ૧૫, ૧૨૬, ૨૨૮, ૩૪૪.)

अवरुंडिज्जइ, सहस्सहुत्तं पि (=सहस्रकृत्वः अपि), पिए जणे (=प्रिये जने 'પ્રિય જનના વિષયમાં'), पुणरुत्तं એ પ્રમાણે જોઈએ.

પ્રાકૃતમાં अवरुंध નહીં પણ अवरुंड આલિંગનવાચક છે. જુઓ દે૦ના૦ ૧, ૧૧. સાહિત્યમાં તે જ વ્યાપકપણે વપરાયો છે.

'પ્રિયજન પુનરુક્ત નથી', એમ કઈ રીતે કહી શકાય? પુનરુક્તિ ક્રિયા હોઈને તે કોઈ ક્રિયા જ નિર્દેશી શકે. પ્રિયજનની બાબતમાં ચુંબન કે આલિંગન આદિનું સેંકડો ને હજારો વાર પુનરાવર્તન થાય તોપણ તેમાં પુનઃ પુનઃ કરાતી ક્રિયાની નીરસતા નથી હોતી—એમ અભિનવગુપ્તે 'લોચન'માં વિવરણ કરતાં કહેલી 'અનુપાદેયતા' ક્રિયાને અનુલક્ષે છે, પ્રિય જનને નહીં. એટલે પ્રથમાનું રૂપ નહીં, પણ સપ્તમીનું રૂપ જોઈએ. આ દૃષ્ટિએ 'વિરમીને વળી રમાય છે' એ પણ બરાબર બંધબેસતું નથી. વિરમવાનો નિર્દેશ સમર્પક નથી. रमिअ पुणो वि रमिज्जइ 'રમીને ફરી પાછો પણ રમાય છે' એમ હોવાનો પૂરતો સંભવ છે. પણ તેવા પાઠ માટે નક્કર સમર્થનની અપેક્ષા રહે છે. સૂચિત પાઠ નીચે પ્રમાણે થશે:

चुबिज्जइ सअहुत्तं[2] अवरुंडिज्जइ सहस्सहुत्तं पि ।
विरमिअ पुणो रमिज्जइ पिए जणे णत्थि पुणरुत्तं ॥

૭. कुविआओ प्रसन्नाओ आरण्णमुहीओ विहसमाणाओ ।
जह गहिओ तह हिअअं हरन्ति उच्छन्तमहिलाओ ।

(ધ્વ૦ ૧/૧૭ નીચે; માં૦, પૃ. ૧૫, ૧૨૬, ૨૨૮, ૩૪૪.)

पसण्णाओ, ओरुण्ण°, गहिआ અને उच्छण्ण કે उच्छिण्ण° જોઈએ. સંસ્કૃત रुदितને અનુરૂપ પ્રાકૃતમાં रुण्ण થાય છે (સિ૦હે૦, ૮-૧-૨૦૯) અને તે પ્રમાણે अवरुदितનું ओरुण्ण (પિશલ, §૫૬૬).

विहसमाणाओमां वि જુદો લેવાથી અર્થ સુધરે છે. गहिओ એવા સ્ત્રીલિંગ પ્રથમા બહુવચનના રૂપ માટે વ્યાકરણ કે પ્રયોગનો આધાર નથી. गहिआ જોઈએ. उच्छन्तने

૨. સિ૦હે૦ ૮-૨-૧૫માં सयहुत्तं અને सहस्सहुत्तं ઉદાહૃત થયા છે, તેનો આધાર કદાચ આ જ ગાથા હોય.

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બદલે કાં તો उच्छण्ण (=उत्सन्न) અથવા તો उच्छिण्ण (=उच्छिन्न) જોઈએ. આ અનુસાર પાઠ નીચે પ્રમાણે થશે :

कुविआओ पसण्णाओ ओरुण्णमुहोओ वि हसमाणाओ ।
जइ गहिआ तह हिअअं हरंति उच्छिण्णमहिलाओ ॥

છાયા : कुपिताः प्रसन्नाः अवरुदितमुख्यः अपि हसन्त्यः ।
यथा गृहीताः तथा हृदयं हरन्ति उच्छिन्नमहिलाः ॥

૮. अज्जाए पहारो णवलदाए दिण्णो पिएण थणवट्टे ।
मिउओ वि दूसहो च्चिअ जाओ हिअए सवत्तीणम् ॥
(ધ્વ૦ ૧/૧૭ નીચે; માં૦, પૃ. ૧૫, ૧૨૬, ૩૪૪.)

च्चिअ, हिअए અને सवत्तीणं જોઈએ. थणवट्ठे એવો પાઠ પણ છે.
થણવટ્ટ=स्तनपट्ट; थणवट्ठ=स्तनपृष्ठ. ગાથા૦ ૨/૫૦માં थणवट्ठे છે.

શ્રી. માંકડે 'નવ-લતાથી પ્રહાર દીધો' એવો, અને ત્રિપાઠીએ 'નવલ-તાને કારણે' (=સૌથી નાની પત્ની હોઈને નવી તથા નાની વયની, અને તેથી કોમળ હોવાથી) એવો અર્થ કર્યો છે, પણ હેમચંદ્રે દે૦ના૦ ૪/૨૧માં જે णवलया નોંધ્યો છે તેની સાથે આ णवलदाने સંબંધ હોવાનો સંભવ છે. 'નવ-લતા' એક લૌકિક ઉત્સવ હતો. હેમચંદ્રે ટાંકેલી કોઈ પુરોગામીની વ્યાખ્યા અનુસાર નવલતા-ઉત્સવમાં બધા લોકો હાથમાં પલાશલતા લઈને ગામમાં ફરે, અને જે સ્ત્રીને તેના પતિનું નામ પૂછવામાં આવે અને તે કહે નહીં તો તેને તે લતાથી પ્રહાર કરવામાં આવે. પ્રસ્તુત ગાથામાંના णवलदाने આ અર્થમાં ન લઈએ તો 'કોમળ લતાથી પ્રહાર દીધો' એવો માંકડે આપેલો અર્થ જ યોગ્ય લેખાશે.

ઉદ્યોત બીજો

૯. गअणं च मत्तमेहं धारालुलिअज्जुणाइँ अ वणाइँ ।
णिरहंकारमिअङ्का हरन्ति नीलाओ वि णिसाओ ॥
(ધ્વ૦ ૨/૧ નીચે; માં૦, પૃ. ૧૯, ૧૨૯, ૨૩૧–૨૩૨, ૩૪૪.)
અહીં वणाइं, °मिअंका તથા हरंति णीलाओ એમ જોઈએ.

૧૦. चमहिअमाणसकञ्चणपङ्कअणिम्महि अपरिमला जस्स ।
अखण्डिअदाणपसारा बाहुप्पलिहा च्चिअ गइन्दा ॥
(ધ્વ૦ ૨/૨૨ નીચે, માં૦, પૃ. ૩૨, ૧૪૧, ૨૫૬, ૩૪૫; કાવ્યા૦, પૃ. ૭૯, ૫૦૭.)

અહીં चमहिअ ભ્રષ્ટ છે; चमढिअ (=मर्दित) જોઈએ; °णिम्महिअपरिमला એમ સાથે જોઈએ. पसाराथी છંદોભંગ થાય છે. કાવ્યા૦માં पसरा છે. अखण्डिअ° કરતાં કાવ્યા૦નો अक्खुडिअ° પાઠ વધારે સારો છે. પાછલા સંયુક્ત વ્યંજનને કારણે प्पलिहा ન જ હોય. प्फलिह જોઈએ. च्चिअने બદલે च्चिअ જોઈએ. આ અનુસાર–

चमढिअमाणसकंचणपंकयणिम्महिअपरिमला जस्स ।
अक्खुडिअदाणपसरा बाहुप्फलिह च्चिअ गइंदा ॥

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११. **सज्जेहि** सुरहिमासो ण दाव अप्पेइ जुअइजणलक्खमुहे ।
अहिणवसहआरमुहे णवपल्लवपत्तले अणङ्गस्स **शरे** ॥

(ધ્વ૦ ૨/૨૫ નીચે; માં૦, પૃ. ૩૬, ૧૪૪, ૨૬૦–૨૬૧, ૩૪૫; કાવ્યા૦ પૃ. ૭૨, ૫૧૨.)

કાવ્યાનુશાસનના सज्जेइ, लक्खसहे અને सरे એ પાઠો જ યોગ્ય છે. दाव अप्पेइने સ્થાને તેમાં या पणामेइ એમ છે. આમાં या અશુદ્ધ છે; ता જોઈએ. ण दाव अप्पेइनो 'ન માત્ર અર્પે છે' એ માંકડે કરેલો અર્થ બરાબર નથી. 'હજી અર્પતો નથી' એ પ્રમાણે અર્થ કરવો જોઈએ. સહકારની કૂંપળો વગેરે શરો વસંત તૈયાર કરે છે, પણ હજી કામદેવને આપતો નથી — શરો હજી આપ્યાં નથી ત્યાં મન્મથનો આટલો પ્રતાપ જણાય છે તો આપ્યા પછી તો તે કેટલો પ્રબળ બનશે : એમ આરંભનો મન્મથ ક્રમે ક્રમે ગાઢ-ગાઢતર બનતો જશે એવી વ્યંજના 'લોચન' તેમ જ 'વિવેક' તારવી આપી છે.

१२. **सिहिपिञ्छकण्णपूरा** जाआ वाहस्स गव्विरी भमइ ।
मुत्ताफलरइअप्रेसाहणाणं मज्झे सवत्तीणम् ॥

(ધ્વ૦ ૨/૨૫ નીચે; માં૦ પૃ. ૩૭, ૧૪૫, ૨૬૧, ૩૪૫; ગા૦સ૦ ૨/૭૩; વેબર ૧૭૩; કાવ્યા૦ પૃ. ૪૨૫, ૫૧૨.)

આ જ ગાથા ધ્વ૦ ૩/૧ નીચે (માં૦ પૃ. ૪૬, ૧૫૩, ૨૭૧, ૩૪૬) પણ આપેલી છે. ત્યાં कण्णऊरा बहुआ અને पसाहणाणँ એવા પાઠો છે. °पिच्छकण्णऊरा અને मुत्ताहल°, पसाहणाण એ પ્રમાણે પાઠ જોઈએ. ગા૦સ૦માં પાઠફેર છે. પહેલી પંક્તિના આરંભમાં सिहिपेहुणावअसा वहुआ એ પ્રમાણે છે, અને બીજી પંક્તિના આરંભમાં मुत्ताहलने બદલે अमोत्तिअ છે. અર્થમાં તાત્ત્વિક ફરક નથી પડતો. પણ पेहुण અને वहुआ એ પાઠો હકારનો वाह° સાથે वहुआ વકારનો અનુપ્રાસ સાધે છે તેથી વધુ યોગ્ય છે. पेहुण(=पिच्छ) દેશ્ય હોઈને, તે અજાણ્યો લાગતાં તેનું સ્થાન पिच्छ શબ્દે લીધું હોય. गअमोत्तिअ (=गजमौक्तिक) સૂચિતને કાંઈક વધુ પ્રકટ કરી દે છે.

१३. **चन्दमऊएहिं** णिसा णलिनी कमलेहिँ कुसुमगुच्छेहिँ लआ ।
हंसेहिँ सरअसोहा कव्वकहा **सज्जनेहिँ करइ** गरुई ॥
(ધ્વ૦ ૨/૨૮ નીચે; માં૦, પૃ. ૩૮, ૧૪૫, ૩૪૫; કાવ્યા૦, ૩૫૫, ૫૦૭.)

मऊहेहिँ, णलिणी, सज्जणेहिँ અને कीरइ એ પ્રમાણે પાઠો જોઈએ.

१४. वीराणं रमइ घुसिणरुणम्मि ण **तदा** पियाथणुच्छङ्गे ।
दिट्ठी रिउगअकुम्भत्थलम्मि जह बहलसिन्दूरे ॥
(ધ્વ૦ ૨/૨૮ નીચે; માં૦, પૃ. ૩૮, ૧૪૬, ૨૬૩, ૩૪૫.)

અહીં वीराण, घुसिणारुणम्मि એમ જોઈએ, અને तदाने બદલે तहा, અને दिट्ठीने બદલે दिट्ठी જોઈએ. માંકડે આપેલા અર્થમાં घुसिण 'કેસર' એ અર્થનો સમાવેશ નથી થયો.

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૧૫. **देव्वाएत्तम्मि** फले किं कीरइ एत्तिअं **पुणा** भणिमो ।
कङ्किल्लपल्लवाः पल्लवाणँ अण्णाण ण सरिच्छा ।।

(ધ્વ૦ ૨/૨૮ નીચે; માં૦ પૃ. ૩૯, ૧૪૬, ૨૬૩–૨૬૪, ૩૪૫; વેબર ૨૭૯; ગા૦સ૦ ૩/૭૯.)

અહીં देव्वाअत्तम्मि, पुणो, कंकेल्लि અને पल्लवाण એમ જોઈએ. ગા૦સ૦માં कीरइને બદલે कीरउ છે અને બીજી પંક્તિ कंकेल्लिपल्लवाणं ण पल्लवा होंति सारिच्छा એ પ્રમાણે છે.

૧૬. हिअअट्ठाविअमण्णुं अवरुण्णमुहं हि मं पसाअन्त ।
अवरद्धस्स वि ण हु दे **पहुजाणअ** रोसिउं **सक्कम्** ।।

(ધ્વ૦ ૨/૨૮ નીચે; માં૦પૃ. ૩૯, ૧૪૭, ૨૬૪, ૩૪૫; કાવ્યા૦ પૃ. ૭૫, ૫૧૩.)

અહીં पहु ને બદલે बहु અને सक्कम् ને બદલે सक्कं જોઈએ.

अवरुण्णमुहंને માટે **अपरोषमुखी** એવી છાયા આપવામાં આવી છે. 'લોચન'માં **अप्रदर्शितरोषमुखीम्** એ પ્રમાણે તેનું વિવરણ આપેલું છે. **अवरुण्णमुहं**એ પાઠમાં બે મુશ્કેલી છે. એક તો સ્ત્રીલિંગ રૂપ **अवरुण्णमुहि** એ પ્રમાણે હોવું જોઈએ, અને બીજું, **अवरुण्ण**નો અર્થ તો 'રડેલું' એવો થાય. જુઓ 'સપ્તશતક' ગાથા ૫૩૯માં તથા 'પાઇઅસદ્દમહણ્ણવો'માં 'ઓરુણ્ણ' અને ગાથાની ટીકામાં **अवरुदितमुखी** એવી સંસ્કૃત છાયા. પણ એ અર્થ અહીં અસંગત છે. મન્યુ ગુપ્તપણે હૃદયમાં રાખેલો હોવાથી નાયિકાના મુખ પર તેનું કોઈ ચિહ્ન નથી (રુદનની નિશાની તો ક્યાંથી હોય?) —એવું અહીં તાત્પર્ય છે. પણ **अवरुण्ण**માંથી એ અર્થ પ્રાપ્ત થતો નથી. એટલે **अवरुट्ठ** જેવો કોઈ પાઠ હોવાની સંભાવના વિચારવી પડે. **रुट्ठ** એટલે કે **रुष्ट**ના વિરોધમાં **अपरुष्ट.** અને તો અર્થ સાથે તે બંધ બેસે. **अवरुट्ठ** ભ્રષ્ટ થઈને **अवरुण्ण** બન્યું હોય. પણ મુશ્કેલી એ છે કે પ્રાકૃતમાં **अवरुट्ठ** જેવો કોઈ પ્રયોગ મળતો નથી.

હવે 'કાવ્યાનુશાસન' ('વિવેક') પ્રમાણે આ ગાથાનો પાઠ જોઈએ :

हिअअट्ठियमन्नुं खु अ अणरुट्ठमुहं पि मं पसायन्त ।
अवरद्धस्स वि ण हु दे बहुजाणय रूसिउं सक्कं ।।

અહીં **अणरुट्ठमुहं** પાઠ છે. **रुट्ठ**નો વિપરીત શબ્દ **अणरुट्ठ** છે, અને યોગ્ય રીતે જ ડૉ. કુલકર્ણીએ તેની છાયા **अरुष्ट** એમ આપેલી છે. આ પાઠ જ સાચો પાઠ છે. **अवरुण्ण**ને બદલે **अणरुट्ठ** જોઈએ.

૧૭. **जायेज्ज** वणुद्देसे **खुज्ज व्विअ** पाअवो **घडिअवत्तो** ।
मा माणुसम्मि लोए ताएक्करसो दरिद्दो अ ।।

(ધ્વ૦ ૨/૨૮ નીચે; માં૦ પૃ. ૩૯, ૧૪૭, ૨૬૪, ૩૪૫; વેબર, ૨૩૦; ગા૦સ૦, ૩/૩૦; કાવ્યા૦, પૃ. ૭૮, ૫૦૮.)

जायेज्जને બદલે **जाएज्ज** અને **खुज्ज व्विअ**ને બદલે **खुज्जो च्चिअ** જોઈએ. **च्चिअ**નો અર્થ **एव** થતો હોવાથી **इव** અર્થને ઘટાવવાની મુશ્કેલી નહીં રહે. કાવ્યા૦માં એ પ્રમાણે જ

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છે. ગા૦સ૦માં ब्विअને બદલે वि हु (=अपि खलु) છે. મુશ્કેલી घडिअवत्तो એ પાઠને લગતી છે[3]. વૃત્તિમાં માંકડે घटितपत्र એવો પાઠ સ્વીકાર્યો છે, પણ તેનો અર્થ 'પત્રહીન' કઈ રીતે થાય? બીજાં સંપાદનોમાં त्रुटितपत्र એવો પાઠ મળે છે. લોચનમાં गलितपत्र એવી છાયા છે. કાવ્યા૦માં ગાથાના પાઠમાં सडिअवत्तो છે, અને વિવેકમાં તેનો અર્થ કે છાયા शटितपत्रः એ પ્રમાણે આપેલી છે.

ગા૦સ૦માં નિર્ણયસાગરવાળા સંપાદનમાં झडिअपत्तो, વેબરમાં सिढिलवत्तो પાઠ સ્વીકારેલા છે, અને વેબરે कुडिअपत्तो અને पडिअपत्तो એવા પાઠ પણ નોંધ્યા છે. આમાં झडिअपत्तो પાઠ સૌથી વધુ સારો છે. વેબરે પણ તેને સારો ગણ્યો છે. शीर्णपत्र અર્થ પણ સુસંગત છે. ઝાડનાં પાંદડાં ગળીને ખરી પડવાના વિશિષ્ટ અર્થમાં झड् વપરાયો છે, અને હિન્દી पतझरમાં પણ આ झड् જ છે. સિ૦હે૦ ૮-૪-૧૩૦ નીચે झड्ને शीर्यतेના આદેશ તરીકે આપ્યો છે.

૧૮. ધ્વ૦ ૨/૨૮ નીચેના ईसाकलुसस्सથી શરૂ થતા ઉદાહરણમાં (માં૦ પૃ. ૪૦, ૧૪૮, ૨૬૫, ૩૪૫; કાવ્યા૦ પૃ. ૭૬, ૫૦૬) विअ (=इव)ને બદલે કાવ્યા૦વાળો च्चिअ (=एव) પાઠ વધુ સારો છે.

૧૯. कमलाअरा ण मलिआ हंसा उड्डाविआ ण अ पिउच्छा ।
केण वि गामतडाए अब्भं उत्ताणअं **फलिहम्** ॥

(ધ્વ૦ ૨/૩૨ નીચે; માં૦, પૃ. ૪૨, ૧૫૦, ૨૬૭, ૩૪૫; વેબર, ૧૧૦; ગા૦સ૦ ૨/૧૦.)

'લોચન'માં આ ગાથાને લગતી જે છાયા આપેલી છે તેમાં મૂળ પાઠ કેટલેક સ્થળે જુદો હોવાનું જણાય છે. मलिना એવી છાયા मलिणा પાઠ માગી લે છે. मलिआની છાયા मृदिता થાય, અને એ જ પાઠ વધુ યોગ્ય છે. ण अ पिउच्छाને સ્થાને 'લોચન'ની પાસે ण अ सहसा પાઠ હતો. પણ અભિનવગુપ્તે पिउच्छा એવું પાઠાંતર હોવાની નોંધ લીધી છે. पिउच्छाનો ચાલુ અર્થ ફઈ છે, પણ 'સખી' એવો પણ તેનો અર્થ થાય છે એ નોંધવું જોઈએ. ગાથાના અંતિમ શબ્દ फलिहम्નો क्षिप्त એવો કોઈ અર્થ થતો નથી. એ પાઠ ભ્રષ્ટ છે. વેબરે આપેલો પાઠ छूढं (=क्षिप्तम्) બરાબર છે. નિર્ણયસાગરનો व्यूढम् પણ ભ્રષ્ટ પાઠ છે. વેબરના અને 'લોચન'ના उत्ताणिअं કરતાં उत्ताणअं વધુ સારો છે.

૨૦. ધ્વ૦ ૨/૩૨ નીચેના वाणीरकुडङ्गो થી શરૂ થતા ઉદાહરણમાં (માં૦ પૃ. ૪૩, ૧૫૦, ૨૬૭, ૩૪૫; કાવ્યા૦ પૃ. ૧૫૨, ૫૧૧; વેબર, ૮૭૪) बहुएने બદલે वहुए જોઈએ, અને તેની છાયામાં शकुनिकुलकोलाहलंને બદલે शकुनिकोलाहलं જોઈએ.

૨૧. उच्चिणसु **पडिअ** कुसुमं मा धुण सेहालिअं हलिअसुण्हे ।
अह दे विसमविरावो ससुरेण सुओ वलअसद्दो ॥

(ધ્વ૦ ૨/૩૨ નીચે; માં૦ પૃ. ૪૩, ૧૫૦, ૨૬૭, ૩૪૫; વેબર, ૯૫૯; કાવ્યા૦ પૃ. ૫૫, ૫૦૬.)

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3. કોઈ આવૃત્તિમાં गडिअवत्तो એમ પણ મળે છે. આ गडिअ પણ ભ્રષ્ટ છે.

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पड्डिअकुसुमं એ પ્રમાણે જોઈએ. **अह**ની છાયા **एषः** ન થાય, **अथ** થાય. વેબરમાં **अह** દેને બદલે **एस** એવો પાઠ છે. એ પાઠની છાયા **एषः** બરાબર છે.

विसमविरावोની છાયા **विषमविरावः** અને અર્થ 'વિષમવિરાવી' એવો કરેલ છે, પણ વલયશબ્દને વિષમવિરાવી કહેવો અહીં અર્થપોષક નથી. 'લોચન'માં **विषमविपाकः** એવી છાયા છે, અને 'સસરા શેફાલિકાની કોમળ લતાની બહુ સાચવણી કરતા હોઈને તેને હલાવવાથી કે તાણવા ખેંચવાથી તેઓ રોષે ભરાશે' એ પ્રકારનું વિષમ પરિણામ અહીં સમજવાનું છે એમ 'લોચન' સ્પષ્ટ કરે છે. આ જોતાં મૂળનો પાઠ **विसमविरावो** નહીં, પણ **विसमविवाओ** (=**विषमविपाकः**) હોવો જોઈએ. વેબરમાં (અને 'કાવ્યાનુશાસન'માં) **अवसाणविरसो** (=**अवसानविरसः**) એવો પાઠ છે અને તેનાથી **विसमविवाओ** એવો પાઠ હોવાના સૂચનનું સમર્થન થાય છે.

A CRITICAL DISCUSSION OF THE TEXT OF THE PRAKRIT ILLUSTRATIVE VERSES FROM DHVANYĀLOKA (UDDYOTA I, II)

H. C. Bhayani

Summary

The text of the Prakrit illustrative verses cited in the **Dhvanyāloka** of Ānandavardhana is in a bad shape due to defective text transmission and the indifference of the Sanskritists. The paper presents a philological discussion of the Prakrit illustrations from the first two Uddyotas of the **Dhvanyāloka,** taking as typical their text as it is given in Prof. D. R. Mankad's recent edition with Gujarati translation and notes (Gujarat University, Ahmedabad, 1969).

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સોલંકી યુગનું સાંસ્કારિક જીવન—એક દૃષ્ટિ*

ભોગીલાલ જ. સાંડેસરા
પ્રાચ્ય વિદ્યામંદિર
એમ. એસ. યુનિવર્સિટી, વડોદરા

ગુજરાત યુનિવર્સિટીના ઉપક્રમે આ વ્યાખ્યાન આપવા માટેના નિમંત્રણ સાર સમાજ-વિદ્યા ભવનના અધ્યક્ષ પ્રો. દેવવ્રત પાઠકનો હું ઉપકાર માનું છું. તેમના સૂચન મુજબ સોલંકી યુગના સાંસ્કારિક જીવન વિષે થોડીક વાતો કરવાનું આજે વિચાર્યું છે. સાંસ્કારિક જીવનમાં ધર્મ અને ધાર્મિક જીવનનો સમાવેશ અવશ્યમેવ થાય. પણ ગયે વર્ષે—૧૯૬૯ના ફેબ્રુઆરીમાં, આ જ વ્યાખ્યાનમાળામાં 'પ્રાચીન અને મધ્યકાલીન ગુજરાતમાં ધર્મજીવન' વિષે એક વ્યાખ્યાન હ. કા. આર્ટ્સ કોલેજમાં મેં આપ્યું હતું, જે કોલેજના મુખપત્ર 'સાબરમતી'(અંક ૧૪, વર્ષ ૧૯૬૮–૬૯)માં અને ત્યારબાદ ગુજરાત વિદ્યાસભાના સામયિક 'બુદ્ધિપ્રકાશ'(જુલાઈ ૧૯૬૯)માં છપાયું હોઈ એ વિષયની વિશેષ ચર્ચા આજે નહિ કરું. એ સિવાય, સોલંકી–વાઘેલા યુગનું કાલાનુક્રમે ઝડપી વિહંગદર્શન કરતાં કરતાં એ સમયના સાંસ્કારિક જીવનની ઝાંખી કરીશું.

ગુજરાતના ઇતિહાસમાં સોલંકી અથવા ચૌલુક્ય કે ચાલુક્ય યુગ ઘણો અગત્યનો છે. એની પૂર્વે ગુજરાતમાં, શ્રીકૃષ્ણના પૌરાણિક યાદવ વંશથી માંડી અનેક રાજવંશો થઈ ગયા હોવા છતાં સમસ્ત ગુજરાત, સૌરાષ્ટ્ર, કચ્છ, માળવા અને રાજસ્થાન ઉપર એકચક્રે રાજ્ય કરનાર આ વંશ ગુજરાતના ઇતિહાસમાં વિશિષ્ટ મહત્ત્વ ધરાવે છે. વલભીના મૈત્રક રાજાઓના સમયમાં તેમની રાજધાની વલભી એટલે અત્યારનું વળા રાજકીય, સાંસ્કારિક અને વેપારી કેન્દ્ર તરીકે ભારે વિકાસ પામ્યું હતું અને વલભીનો એ વારસો શ્રીમાલ અને અણહિલપુર પાટણને મળ્યો હતો એ ખરું, પણ અર્વાચીન ગુજરાતના વ્યક્તિત્વની સંઘટનાનો આરંભ તો વિક્રમના દસમા સૈકાના અંતમાં પાટણમાં સોલંકી વંશની સ્થાપના સાથે થયો તથા એ પછીના આશરે બે સૈકામાં એ વ્યક્તિત્વ સ્પષ્ટ અને સુરેખ બન્યું. આપણા પ્રદેશની ભાષાનું અપભ્રંશમાંથી જૂની ગુજરાતી તરીકેનું પાર્થક્ય પણ એ સમયમાં સ્ફુટ થયું એટલું જ નહિ પણ એ સમયમાં ચાલી રહેલી સઘન વિદ્યાપ્રવૃત્તિ તથા એના ફલસ્વરૂપ વ્યાપક અને વિવિધ સાહિત્યરચનાને કારણે ભાષાનો ઝડપી વિકાસ થયો.

આપણા પ્રાન્ત માટે 'ગુજરાત' એવું પ્રદેશવાચક નામ એ સમયમાં જ પ્રચલિત થયું. યાયાવર ગુર્જર ટોળીઓના પરિભ્રમણ સાથે 'ગુજરાત'નું પણ સ્થળાન્તર થતું રહ્યું છે. પંજાબમાં—

* ગુજરાત યુનિવર્સિટીની વિદ્યાવિસ્તાર વ્યાખ્યાનમાળામાં, સમાજવિદ્યા ભવનમાં તા. ૨૮ જાન્યુઆરી ૧૯૭૦ના રોજ આપેલું વ્યાખ્યાન.

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હવે પશ્ચિમ પાકિસ્તાનમાં—'ગુજરાત' જિલ્લો છે. મારવાડ અને આસપાસના પ્રદેશમાં ગુર્જર જાતિનું રાજ્ય થતાં એ પ્રદેશ ઈસવી સનના છઠ્ઠા સૈકા લગભગ 'ગૂર્જરત્રા', 'ગૂર્જરાત્રા', 'ગુજ્જરત્તા', 'ગુર્જરાટ', 'ગુર્જરદેશ' આદિ નામે ઓળખાવા લાગ્યો. સંભવ છે કે લોકભાષામાં ગુર્જર પ્રજાના સમુદાયનો અર્થ વ્યક્ત કરતું 'ગુજરાત' નામ જ પ્રચલિત હોય, જેનાં આ બધાં સંસ્કારેલાં કૃત્રિમ રૂપો હોય. આ પ્રદેશના રાજાઓ પણ ગુર્જર રાજાઓ તરીકે ઓળખાયા. મૂળરાજ સોલંકીનો પિતા રાજ અથવા રાજિ આ ગુર્જર પ્રદેશનો રાજા હોય અને તેથી અણહિલવાડમાં તેના રાજ્યઅમલની સ્થાપના સાથે તેના શાસિત પ્રદેશને પણ એ નામ મળ્યું એવું કેટલાક ઇતિહાસવિદોનું અનુમાન છે.

સંસ્કૃત—પ્રાકૃત સાહિત્યમાં અને ઉત્કીર્ણ લેખોમાં પ્રયોજિત પેલાં સંસ્કારેલાં નામોની નહિ પણ 'ગુજરાત' એ નામની વાત કરીએ તો, અગિયારમા સૈકાનો લેખક અલબિરુની 'ગુજરાત'નો ઉલ્લેખ કરે છે, એટલું જ નહિ, પણ લાટ દેશ અણહિલવાડની દક્ષિણે ૧૭૦ માઈલ દૂર આવેલો છે એમ જણાવે છે. સં. ૧૨૮૯(ઈ.સ. ૧૨૩૩)માં રચાયેલા પાલ્હણના 'આબુરાસ'માં અને સં. ૧૨૯૦(ઈ.સ. ૧૨૩૪)ના 'પ્રબન્ધસંગ્રહ'માં ઉદ્ધૃત થયેલા રાણકદેવીના લોકદૂહામાં 'ગુજરાત'નો પ્રયોગ છે. એ પછી પ્રભાચન્દ્રસૂરિકૃત 'પ્રભાવકચરિત' (સં. ૧૩૩૪ : ઈ.સ. ૧૨૭૮)માં ઉદ્ધૃત થયેલા અપભ્રંશદૂહામાં અને અજ્ઞાત કવિકૃત 'જિનચંદસૂરિફાગુ' (સં. ૧૩૪૧ : ઈ.સ. ૧૨૮૫)માં 'ગુજરાત'નો પ્રયોગ છે તથા એ જ સમયનો ઇટાલિયન મુસાફર માર્કો પોલો પોતાના પ્રવાસવર્ણનમાં 'ગુજરાત'નો ઉલ્લેખ કરે છે. આ ઉલ્લેખો મુસ્લિમ રાજ્યકાળ પૂર્વેના છે. અલબિરુની અને માર્કો પોલો જેવા પરદેશીઓએ તો તે કાળની જીવતી ભાષામાંનો પ્રચલિત પ્રયોગ જ સાંભળીને નોંધ્યો હોવો જોઈએ. એમાં કાલાનુક્રમે સૌથી પહેલો, અલબિરુનીનો ઉલ્લેખ ધ્યાનમાં લેતાં, આપણા પ્રાન્ત માટે—ખાસ કરીને ઉત્તર અને મધ્ય ગુજરાત માટે—'ગુજરાત'એ નામ ઈસવી સનના દશમા સૈકામાં સોલંકી યુગની સ્થાપના સાથે વિશેષ પ્રચારમાં આવ્યું હોવું જોઈએ એ અનુમાનને સાધાર સમર્થન મળે છે. રાજ્યના વિસ્તાર સાથે આ શબ્દપ્રયોગનો પણ અર્થવિસ્તાર થયો છે એ સ્પષ્ટ છે.

ગુજરાતનો અભૂતપૂર્વ રાજકીય વિસ્તાર એ કાળે થયો; અને પરિણામે આર્થિક અને વ્યાપારી વિકાસ થતાં સમૃદ્ધિ વધી અને એ સાથે વિદ્યાકળાને પણ મોટો વેગ મળ્યો. અનેક અમર સ્થાપત્ય કૃતિઓની રચના થઈ; આચાર્ય હેમચન્દ્ર તથા એમના શિષ્યમંડળ દ્વારા, મહામાત્ય વસ્તુપાલની આસપાસ એકત્ર થયેલા વિદ્વન્મંડળ દ્વારા તથા વિદ્યા અને સંસ્કારથી પરિપ્લુત વાતાવરણમાં પાકેલા અનેક કવિ પંડિતો દ્વારા શાસ્ત્રીય તેમ જ લલિત વાઙ્મયનાં ક્ષેત્રોમાં મૂલ્યવાન સંસ્કૃત-પ્રાકૃત ગ્રંથોનું પ્રદાન કરીને તથા ઉત્તરકાલીન અપભ્રંશ અને મારુ-ગુર્જર સાહિત્યના વિવિધ પ્રકારોનું પર્યાપ્ત ખેડાણ કરીને ગુજરાતે ભારતીય સાહિત્યમાં પણ કીમતી ફાળો આપ્યો.

વાઘેલા એ સોલંકીઓની જ એક શાખા છે. કોઈ સ્વતંત્ર રાજવંશ નથી. રાજા કુમારપાલે પોતાના માસીના દીકરા અર્ણોરાજ અથવા આનાકને હારીજ પાસેનું વાઘેલ ગામ જાગીર તરીકે આપ્યું હતું. આ 'વાઘેલ'નું સંસ્કૃત રૂપ પ્રબન્ધો અને ઉત્કીર્ણ લેખોમાં 'વ્યાઘ્રપલ્લી' એવું મળે છે. વાઘેલ ગામના તે વાઘેલા. તેરમા સૈકામાં થયેલા ચૌલુક્યોના રાજપુરોહિત સોમેશ્વરે

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આબુ ઉપર વસ્તુપાલના મન્દિરના પ્રશસ્તિલેખમાં વાઘેલાના મૂળ પુરુષ અર્ણોરાજની વાત કરતાં કહ્યું છે—

इतश्चौलुक्यवीराणां वंशे शाखाविशेषकः ।
अर्णोराज इति ख्यातो जातस्तेजोमयः पुमान् ।। (શ્લોક ૨૫)

[આ તરફ ચૌલુકય વીરોના વંશમાં તેમની શાખાના તિલકરૂપ, અર્ણોરાજ નામથી વિખ્યાત એક તેજસ્વી પુરુષ પેદા થયો.]

વાઘેલાઓનો રાજ્યકાળ એ સોલંકી યુગનું જ સાતત્ય છે. અર્ણોરાજના વંશમાં થયેલા રાણા લવણપ્રસાદ અને તેના પુત્ર વીરધવલનું રાજ્ય ધોળકામાં હતું અને તેઓ પાટણની સાર્વભૌમ સત્તાના મંડલેશ્વરો હતા. વીરધવલના પુત્ર વીસલદેવે કેટલોક સમય ધોળકામાં રાજ્ય કર્યું, પણ સંવત ૧૩૦૦(ઈ.સ. ૧૨૪૪)માં પાટણના સોલંકી રાજા ત્રિભુવનપાલનું અવસાન થતાં તે અપુત્ર હોવાને કારણે અથવા બીજા કોઈ અનુકૂળ સંજોગોમાં મહારાજાધિરાજનું પદ ધારણ કરી વીસલદેવ પાટણની ગાદી ઉપર બેઠો ત્યારથી સોલંકીઓની વાઘેલા શાખાનું રાજ્ય સમસ્ત ગુજરાત ઉપર થયું, અને સંવત ૧૩૬૦(ઈ.સ. ૧૩૦૪)માં એ શાખાના છેલ્લા રાજા કર્ણ વાઘેલાનો અલાઉદ્દીન ખિલજીના સૈન્ય સામે પરાજય થયો ત્યાં સુધી ચાલુ રહ્યું.

આમ જોઈ શકાશે કે ગુજરાતમાં સોલંકી રાજવંશ ઘણા લાંબા સમય સુધી ચાલ્યો. સંવત ૯૯૮(ઈ.સ. ૯૪૨)માં એની સ્થાપના કરનાર મૂલરાજ સોલંકી પાટણની ગાદીએ આવ્યો ત્યારથી સંવત ૧૩૬૦(ઈ.સ. ૧૩૦૪)માં વાઘેલાઓનો અસ્ત થયો ત્યાર સુધીનાં આશરે પોણાચારસો વર્ષ આ રાજવંશનાં છે. કોઈ પણ રાજવંશ આટલા લાંબા સમય સુધી લગભગ એકસરખા ઉત્કર્ષપૂર્વક સ્થિર રહે અને પ્રજાજીવનનાં વિવિધ અંગો પણ એની સાથે અભ્યુદય પામીને વિકાસ સાધતાં રહે એ ઇતિહાસમાં વારંવાર જોવા મળે નહિ એવી ઘટના છે.

સોલંકીઓએ પોતાનું કોઈ નવું નગર વસાવ્યું નહોતું, પણ પુરોગામી ચાવડા વંશની રાજધાની અણહિલવાડ પાટણને જ રાજધાની તરીકે ચાલુ રાખ્યું હતું. પાટણની સ્થાપના પહેલાં, ઈસવી સનના સાતમા—આઠમા સૈકામાં, ચાવડાઓનાં ઓછામાં ઓછાં ત્રણ રાજ્ય પ્રાચીન ગુર્જર દેશમાં હતાં—શ્રીમાલમાં, વઢવાણમાં અને પંચાસરમાં. એમાંથી પંચાસરના જયશિખરીના પુત્ર વનરાજે સંવત ૮૦૨(ઈ.સ. ૭૪૬)માં, સરસ્વતીના તીરે, લાકખારામ નામે જૂના ગામની જગાએ પોતાના મિત્ર અણહિલના નામથી અણહિલવાડ પાટણ વસાવ્યું. પ્રાકૃત 'લાકખારામ'નું સંસ્કૃતરૂપ लक्षाराम થાય. સારસ્વતમંડલ અને બનાસકાંઠો એકંદરે સૂકો અને વનરાજિ વિનાનો હોવા છતાં સરસ્વતી અને બનાસનો તીરપ્રદેશ વૃક્ષમંડિત છે.* લાકખારામમાં પણ અગણિત વૃક્ષો હોય એમ બને. ગિરનાર ઉપરનું સહસ્રામ્રવન, જે લોકબોલીમાં સહેસાવન તરીકે ઓળખાય છે તેનું નામ પણ લાકખારામ સાથે સરખાવી શકાય. પણ આ તો

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* પાટણના કોટ નજીકની વનાવલિનું સોમેશ્વરે 'કીર્તિકૌમુદી'માં કરેલું ટૂંકું પણ સુરેખ વર્ણન અહીં સરખાવો:

अनेकानोकहच्छन्ना प्रत्यासन्ना वनावलिः ।
यत्रोन्नतस्य वप्रस्य छायेव प्रतिभासते ।। (સર્ગ ૧, શ્લોક ૫૦)

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64277

સહેજ આડ વાત થઈ. વનરાજે પાટણમાં સ્થાપેલો ચાવડા વંશ, ઉપલબ્ધ સાધનો પ્રમાણે ૧૯૬ વર્ષ ચાલ્યો, પરંતુ ચાવડાઓ વિષેનો સર્વપ્રથમ ઐતિહાસિક ઉલ્લેખ પાટણની સ્થાપના પછી ચારસો-છ વર્ષ બાદ સિદ્ધરાજ અને કુમારપાલના પ્રજ્ઞાચક્ષુ રાજકવિ શ્રીપાલે રચેલી કુમારપાલની વડનગર પ્રશસ્તિ(સંવત ૧૨૦૮ : ઈ.સ. ૧૧૫૨)માં મળે છે એ આશ્ચર્યજનક છે. ચાવડાઓનું રાજ્ય આરંભમાં નાનકડી ઠકરાત જેવું હતું એ અનુમાનનું આથી સમર્થન થાય છે. પણ ઈ.સ. ૯૪૨માં મૂલરાજ સોલંકી ગાદીએ આવ્યો ત્યાર પછી જ મોટા રાજકીય, વેપારી અને સાંસ્કૃતિક કેન્દ્ર તરીકે પાટણનો વિકાસ થયો એવી એક માન્યતા ઇતિહાસવિદોમાં પ્રચલિત છે તે હવે સાધાર લાગતી નથી. સ્વયંભૂ કવિએ ઈ.સ. ૮૪૦ અને ૯૨૦ની વચ્ચે કર્ણાટકમાં રચેલા અપભ્રંશ મહાકાવ્ય 'પઉમચરિઉ'માં એક સુવિખ્યાત મહાનગર अइवड्डउ તરીકે અણહિલવાડ પાટણનો ઉલ્લેખ કર્યો છે એ બતાવે છે કે ગુજરાતમાં સોલંકી વંશના રાજ્યકાળ પૂર્વે જ એ પ્રચલિત થયું હતું અને દૂર કર્ણાટક સુધી (સંભવતઃ ભારતના બીજા ભાગોમાં પણ) જાણીતું થયું હતું. વળી તે એમ પણ દર્શાવે છે કે ચાવડાઓનું રાજ્ય શરૂઆતમાં નાની ઠકરાત જેવું હશે, પણ નિદાન ઉત્તરકાલીન ચાવડા રાજાઓના સમયમાં એની રાજધાની 'અતિવિશાળ' નગર (अइवड्डउ) રૂપે વિકસી હતી. અર્થાત્ મૂલરાજને ચાવડાઓ પાસેથી જ એક આબાદ નગર મળ્યું હતું, જેની જાહોજહાલી સોલંકી યુગમાં કુમારપાલના સમય સુધી ઉત્તરોત્તર વધતી ગઈ ('બુદ્ધિપ્રકાશ,' માર્ચ ૧૯૬૨માં મારો લેખ 'अइवड्डउ અણહિલવાડ પાટણનું એક પર્યાયનામ,' 'અન્વેષણા' પૃ. ૧૭૯–૮૩). ગુજરાતની શ્રી અને સંસ્કૃતિનું પાટણ એવું કેન્દ્ર બન્યું કે કેટલીક સદીઓ સુધી પાટણ અને ગુજરાત જાણે કે પર્યાયરૂપ બની ગયાં.

ગુજરાતના સોલંકી વંશના પ્રથમ રાજ્યકર્તા મૂલરાજનો પિતા રાજ કે રાજિ કનોજ કે દક્ષિણથી નહિ, પણ ભીનમાલથી આવ્યો હોવાનું અને તે કનોજનો સામંત હોવાનું અનુમાન શ્રી. દુર્ગાશંકર શાસ્ત્રીએ કર્યું છે. આબુ ઉપર વિમલવસતિ બંધાવનાર વિમલમંત્રીના પૂર્વજોને લગતો પરંપરાગત વૃત્તાન્ત તથા એ પ્રકારની બીજી અનુશ્રુતિઓ બતાવે છે કે ઠેઠ વનરાજ ચાવડાના સમયથી ભીનમાલ આસપાસની વસ્તીનું ઉત્તર ગુજરાત તરફ સ્થળાન્તર શરૂ થઈ ચૂક્યું હતું અને સારસ્વતમંડલને સમૃદ્ધ બનાવવામાં તેનો સારો હિસ્સો હતો.

મૂલરાજ એ છેલ્લા ચાવડા રાજા સામંતસિંહનો ભાણેજ હતો અને દારૂના ઘેનમાં પોતાને રાજ્યને બક્ષિસ કર્યા પછી તે પાછું માગનાર મામાનો વધ કરીને ગાદીએ આવ્યો હતો એવી પ્રબન્ધાદિમાં નોંધાયેલી વાત શ્રી. દુર્ગાશંકર શાસ્ત્રી માનતા નથી. મૂલરાજનું માતૃકુળ ચાવડાઓમાં હોય કે ન હોય, પણ છેલ્લા ચાવડા રાજાને મારી કે હરાવીને મૂલરાજે પાટણનું રાજ્ય કબજે કર્યું હોય તથા સુરાપાન અને લૂંટફાટની પ્રવૃત્તિને કારણે નબળા પડી ગયેલા ચાવડા શાસકોને પરાજિત કરવાનું મૂલરાજ માટે સરળ બન્યું હોય એ તદ્દન સંભવિત છે.

મૂલરાજ એક દીર્ઘદૃષ્ટિવાળો રાજ્યકર્તા અને કુશળ સેનાપતિ હતો. ચાવડાઓ પાસેથી મેળવેલા નાનકડા રાજ્યનો વિસ્તાર કરીને તેણે સોલંકીઓના ભાવિ સામ્રાજ્યનો પાયો નાખ્યો. લાટમાં દક્ષિણના ચાલુક્યોના દંડનાયક બારપનો, સુરાષ્ટ્રના રાજવી ગ્રહરિપુનો તથા લોકસાહિત્યમાં અમર બનેલા કચ્છના રાજા લાખા ફુલાણીનો તેણે પરાજય કર્યો; અને એ રીતે દક્ષિણ ગુજરાત, સૌરાષ્ટ્ર અને કચ્છમાં રાજ્યવિસ્તાર કર્યો. જોકે મૂલરાજના વંશજોને લાટ અને

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સુરાષ્ટ્ર સાથે પછીના સમયમાં જે યુદ્ધો કે વિગ્રહો કરવાના થયા એ જોતાં લાગે છે કે મૂલરાજના આ વિજયો તાત્કાલિક અધૂરા વિજયો હશે. પણ પાટણના નાના રાજ્ય માટે એમાં ભાવી વિસ્તારની એંધાણીઓ હતી.

મૂલરાજે સિદ્ધપુરમાં રુદ્રમહાલય બાંધ્યો, જેનાં ભવ્ય ખંડેરો આજે જોવા મળે છે. ડૉ. દેવદત્ત ભાંડારકરના મત મુજબ, ભારતનાં મહત્તમ ધાર્મિક સ્થાપત્યો પૈકી રુદ્રમહાલય એક છે. સિદ્ધરાજ જયસિંહે રુદ્રમહાલય બંધાવ્યો હતો એવા પણ અનેક ઉલ્લેખો અને વર્ણનો ઐતિહાસિક સાધનોમાં છે. મૂલરાજે રુદ્રમહાલય બાંધ્યો હોય અને સિદ્ધરાજે એનો વિસ્તાર અથવા જીર્ણોદ્ધાર કર્યો હોય એ વિશેષ સંભવિત લાગે છે. રુદ્રમહાલયના બાંધકામની દેખરેખ માટે સિદ્ધરાજે નિયુક્ત કરેલ મંત્રી આલિગે સિદ્ધપુરમાં રુદ્રમહાલયના સ્થાપત્યને અનુરૂપ રાજવિહાર નામે જૈન મંદિર બાંધ્યું હતું. (આ જૈન મંદિરના પ્રતિષ્ઠા મહોત્સવ પ્રસંગે સિદ્ધરાજે કેટલાંક ગામ એને દાનમાં આપ્યાં હતાં તે ઉપરથી એનું નામ રાજવિહાર પડ્યું હશે?) રાજવિહારનું તો અત્યારે અસ્તિત્વ નથી, પણ સં. ૧૪૯૬માં મારવાડમાં રાણકપુરનું ધરણવિહાર નામે વિખ્યાત જૈન મંદિર મંત્રી ધરણાશાહે રાજવિહારના નમૂના ઉપરથી બંધાવ્યું હતું એમ પંડિત પ્રતિષ્ઠાસોમના 'સોમસૌભાગ્ય કાવ્ય'(સર્ગ ૯, શ્લોક ૪૭–૪૮)માંથી જાણવા મળે છે. ધરણાશાહના મુખ્ય સ્થપતિ દેપાએ સિદ્ધપુર આવી રાજવિહાર જોયા પછી ધરણવિહારનો નકશો બનાવ્યો હતો એમ ધરણવિહારની પ્રતિષ્ઠા પછી ત્રણ જ વર્ષે, સં. ૧૪૯૯માં મેહ કવિએ એ મંદિરના મારુ–ગુર્જર સ્તવનમાં કહ્યું છે. છેલ્લી અનેક સદીઓમાં રુદ્રમહાલયમાં એટલી ભાંગ-ફોડ થઈ છે અને તેનો એટલો ઓછો ભાગ અવશિષ્ટ રહ્યો છે કે રાણકપુરના મંદિરની આયોજના સાથે તેનું પ્રત્યક્ષ સામ્ય બતાવવું મુશ્કેલ છે. પણ એ માટેના સાહિત્યિક પુરાવા પૂરતા સબળ છે. મતિસારકૃત 'કર્પૂરમંજરી ચોપાઈ' અને કનકસુન્દરકૃત 'કર્પૂરમંજરી રાસ' એ બે જૂની ગુજરાતી પદ્ય-વાર્તાઓમાં નાયિકાના સ્થાને રુદ્રમહાલયમાંની એક અદ્ભુત સૌન્દર્યવતી પૂતળી કર્પૂરમંજરી છે એ બતાવે છે કે ગુજરાતના લોકમાનસમાં પણ રુદ્રમહાલય અને એમાંનાં સ્થાપત્યોએ કેવું વિશિષ્ટ સ્થાન મેળવ્યું હતું.

રુદ્રમહાલય એક ભવ્ય શૈવ સ્થાપત્ય છે. મૂલરાજે સિદ્ધપુરમાં મૂલનારાયણનું વિષ્ણુમંદિર પણ બાંધ્યું હતું. રાજવિહારની જેમ જ મૂલનારાયણના મંદિરનો સ્થાનનિર્ણય થઈ શકે એમ નથી. એના અસ્તિત્વની ભાળ પણ એક ગ્રન્થપુસ્તિકામાંથી મળે છે. જેસલમેરના બડા ભંડારમાં સચવાયેલી, 'સાંખ્યસપ્તતિટીકા'ની એક તાડપત્રીય હસ્તપ્રતની પુષ્પિકામાં કહ્યું છે કે— "સં. ૧૨૦૦ના શ્રાવણ વદ ૮ ગુરુવારે અહીં સિદ્ધપુરમાં શ્રીમૂલનારાયણ દેવના મઠમાં રહેતા પરમ ભાગવત તપોધનિક શ્રી ઋષિમુનીન્દ્રના શિષ્ય પરમાર્થવિદ શ્રી સલ્હણમુનિના વિનેય આલ્હણની આજ્ઞાથી પંડિત ધારાદિત્યે સાંખ્યસપ્તતિટીકાની ભવ્ય--સરસ પુસ્તિકા લખી" ('જૈન પુસ્તકપ્રશસ્તિ સંગ્રહ', ભાગ ૧, પૃ. ૧૦૫). આ બતાવે છે કે મૂલનારાયણનું મંદિર અને મઠ કુમારપાલના સમય સુધી વિદ્યમાન હતાં અને વિદ્યાકેન્દ્ર તરીકે કાર્યશીલ હતાં. (વાઘેલા રાણા વીરધવલે ધોળકામાં બંધાવેલું વીર નારાયણનું મંદિર અહીં યાદ આવે. એનો પ્રશસ્તિલેખ કવિ સોમેશ્વરે રચેલો હતો. ધોળકામાં પણ એ મંદિરનો સ્થાનનિર્ણય અત્યારે તો અશક્ય છે.) મૂલરાજના નામ વડે અંકિત અન્ય સ્થાપત્યોમાં માંડલી–માંડલમાં મૂલેશ્વર મહાદેવ

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તથા પાટણમાં મૂલદેવ સ્વામીનું મંદિર અને મૂલરાજવસહિકાના ઉલ્લેખો પ્રબન્ધોમાં છે. મૂલદેવસ્વામી એ સૂર્યમંદિર સંભવે છે, જ્યારે મુલરાજવસહિકા એ જૈન મંદિર હતું. પાટણમાં મૂલરાજે બાંધેલું સૌથી વિખ્યાત મંદિર તો ત્રિપુરુષપ્રાસાદ હતું, જેના ચિન્તાયક અથવા મઠપતિ તરીકે સરસ્વતીના તીરે વસતા તપસ્વી કંથડીના શિષ્ય વૈજલદેવની નિયુક્તિ થઈ હોવાની કથા જાણીતી છે. ત્રિપુરુષપ્રાસાદના સ્થાનનો નિશ્ચિતપણે પત્તો અત્યારે મળતો નથી, પણ પાટણમાં સાલવીવાડમાં હાલ ત્રિપુરેશ્વર મહાદેવનું મંદિર છે એ સ્થળ ઉપર ત્રિપુરુષપ્રાસાદ હતો એવી સ્થાનિક અનુશ્રુતિ છે અને એને નિરાધાર માનવાનું કોઈ સબળ કારણ નથી. (ત્રિપુરેશ્વર મહાદેવના ચાંદી નીચેના શિલાલેખમાં કહ્યું છે કે—સં. ૧૪૯૯માં નવીન ચાંદીની પ્રતિષ્ઠા પોરવાડ શ્રેષ્ઠીએ કરાવી.) ગમે તેમ, પણ ઘણા સમય સુધી એ મંદિર, પ્રાચીન કાળનાં અનેક પ્રસિદ્ધ મન્દિરોની જેમ, સંસ્કારકેન્દ્ર જેવું હતું અને ત્યાં વિવિધ પ્રકારના જાહેર સમારંભો પણ થતા. ત્રિપુરુષપ્રાસાદ બંધાયા પછી લગભગ અઢીસો–પોણા-ત્રણસો વર્ષ બાદ, વિક્રમના તેરમા શતકના ઉત્તરાર્ધમાં પણ આ પરિપાટી ચાલુ રહેલી જણાય છે, કેમકે એ અરસામાં શ્રીપાલના પુત્ર કવિ વિજયપાલકૃત સંસ્કૃત 'દ્રૌપદીસ્વયંવર' નાટક રાજા ભીમદેવ બીજાની આજ્ઞાથી ત્રિપુરુષપ્રાસાદમાં વસંતોત્સવ પ્રસંગે ભજવાયું હતું. ઉત્તરાપથના વિદ્વાન બ્રાહ્મણોને અનેક પ્રકારનાં દાન આપી ગુજરાતમાં વસાવીને, 'કર્મયોગી રાજેશ્વર'ના લેખક શ્રી. ચૂનીલાલ વર્ધમાન શાહના શબ્દોમાં કહું તો, મૂલરાજે 'જ્ઞાનસંસ્કારની પરબો' બેસાડી હતી. આ બ્રાહ્મણો પછીથી ઉદીચ્ય કે ઔદીચ્ય બ્રાહ્મણો તરીકે ઓળખાયા. કિંવદન્તીઓમાં જણાવ્યું છે તેમ, મામાનો વધ કરી રાજ્ય મેળવ્યા બદલ થયેલા પશ્ચાત્તાપને કારણે મૂલરાજે પોતાની ઉત્તરાવસ્થામાં ધાર્મિક કાર્યો કર્યાં હતાં એવો કેટલાક અભ્યાસીઓનો મત છે.

મૂલરાજની ચોથી પેઢીએ થયેલા ભીમદેવ પહેલો અથવા ભીમ બાણાવળીના રાજ્યકાળમાં, સોમનાથનો ભંગ કરનાર મહમૂદ ગઝનવીની સવારી ગુજરાત ઉપર આવી. ફાર્બસ સાહેબના 'રાસમાલા' એક સદી કરતાં વધુ સમય પહેલાં પ્રકટ થઈ ત્યારથી એવો ખ્યાલ પ્રચલિત છે કે મહમૂદ ગઝનવીની સવારી વિષે અત્રત્ય સાહિત્યમાં કોઈ ઉલ્લેખો નથી. પણ આ માન્યતા વાસ્તવિક નથી. ભોજ અને ભીમના સમકાલીન ધનપાલ કવિનું 'સત્યપુરમંડન મહાવીરોત્સાહ' નામે અપભ્રંશ કાવ્ય જે સાચોરના મહાવીર સ્વામીના મન્દિરનું સ્તવન છે એની ત્રીજી કડીમાં શ્રીમાલ, અણહિલવાડ, ચંદ્રાવતી, દેલવાડા અને સોમનાથમાં મહમૂદના ઉપદ્રવનો સ્પષ્ટ ઉલ્લેખ છે. જિનપ્રભસૂરિકૃત 'વિવિધ તીર્થકલ્પ'માં (આ ગ્રન્થ ઈ. સ. ૧૩૩૩માં પૂરો થયો) સત્યપુર કલ્પ અને હરિકંખી કલ્પમાં એમ બે સ્થળે આ આક્રમણની સ્પષ્ટ નોંધ છે. આ ઉપરાંત કેટલાક ઉત્કીર્ણ લેખો અને સાહિત્યિક સાધનોમાં આ વિષે મોઘમ ઉલ્લેખો છે એ શ્રી. રામલાલ મોદીએ બતાવ્યું છે ('સ્વ. રા. ચુ. મોદી લેખસંગ્રહ', ભાગ ૨, પૃ. ૪૩–૪૮). અર્થાત્ અત્રત્ય લેખકોએ એ વિષે મૌન સેવ્યું છે એમ હવે કહેવુ એ બરાબર નથી. અણધાર્યા આવેલા આ વંટોળથી ભારે ઉત્પાત મચી રહ્યો, પણ થોડા સમયમાં ગુજરાતે પોતાનું જીવન પૂર્વવત્ શરૂ કર્યું અને ભીમદેવના પુત્ર કર્ણના સમયમાં ગુજરાત અને પાટણની પાછી ઊર્ધ્વગતિ શરૂ થઈ.

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કર્ણ એ સિદ્ધરાજ જયસિંહનો પિતા. કર્ણ અને મીનલદેવીનાં લગ્નની વાત પ્રબન્ધોમાં વિસ્તારપૂર્વક આપી છે. 'દ્વયાશ્રય' મહાકાવ્યમાં મીનળદેવીને ચંદ્રપુરના કાદંબવંશીય રાજા જયકેશીની પુત્રી કહી છે, જ્યારે 'પ્રબન્ધચિન્તામણિ'માં જયકેશીને કર્ણાટકનો રાજા કહ્યો છે. જયકેશી અને કદંબવંશ ગોવામાં રાજ્ય કરતા હતા એ હવે નક્કી થયું છે. આ પહેલાં ગુજરાતના રાજાનો દક્ષિણના કોઈ રાજ્ય સાથે લગ્નસંબંધ થયો નહોતો, એ કારણે પ્રબન્ધકારોએ આ લગ્નને વધુ મહત્ત્વ આપ્યું હોય એમ બને. લાટના ચાલુક્યને હરાવી કર્ણે આખો લાટ કબજે કર્યો હતો, તેથી પણ દક્ષિણ સાથેનો ગુજરાતનો સંપર્ક અને સંબંધ વધારે સરલ અને ગાઢ બન્યો હોય.

કર્ણનો પુત્ર જયસિંહ જેને સિદ્ધરાજ બિરુદ અપાયું હતું તે એક મહત્ત્વાકાંક્ષી, પરાક્રમી અને વિદ્યારસિક રાજા હતો. ગુજરાત અને માળવા વચ્ચે એ કાળે તીવ્ર રાજકીય સ્પર્ધા ચાલતી હતી. મૂલરાજના પુત્ર ચામુંડના સમયથી માંડી ઠેઠ ઈસવી સનની તેરમી સદીના અંતમાં સારંગદેવ વાઘેલાના રાજ્યકાળ સુધી ગુજરાત અને માળવા વચ્ચે વારંવાર યુદ્ધો ચાલ્યાં કરતાં હતાં. માળવા સાથેના ગુજરાતના સતત વિગ્રહનું એક કારણ ભરૂચ બંદરનો કબજો મેળવવાનો માળવાનો સતત પ્રયત્ન હતો, કેમકે ચારે બાજુ જમીનથી ઘેરાયેલ સમૃદ્ધ અવન્તીની લક્ષ્મી એકે બંદર વિના રુંધાતી હતી. સં. ૧૧૯૨-૯૩ના અરસામાં સિદ્ધરાજે માળવા ઉપર વિજય કર્યો અને અમુક સમય સુધી તો માળવા ગુજરાતના સામ્રાજ્યનો ભાગ બન્યું. માળવાના પાટનગર ધારામાં સિદ્ધરાજે ત્યાંનો સરસ્વતી ભંડાર જોયો; ભોજ રાજાના વિદ્યાવિનોદોના કેન્દ્રસ્થાન એના સરસ્વતી સદન અથવા શારદાસદ્મનું દર્શન પણ તેણે કર્યું હશે. ગુર્જર ભૂમિને પણ સંસ્કૃત વિદ્યાથી આપ્લાવિત કરવાની મહત્ત્વાકાંક્ષા એને સ્વાભાવિક રીતે થઈ. મુખ્યત્વે એની પ્રેરણાથી આચાર્ય હેમચન્દ્રે એ કાળે ખેડાતી વિદ્યાની તમામ શાખાઓમાં પ્રમાણભૂત ગ્રન્થોની રચના કરી, અને 'કલિકાલસર્વજ્ઞ' તરીકે વિખ્યાત થયા. માળવાના વિદ્યા-વિલાસી રાજાઓ મુંજ અને ભોજની જેમ સિદ્ધરાજની સભા પણ દેશવિદેશના વિદ્વાનોનું મિલનસ્થાન બની હતી; અનેક પ્રકારના વિદ્યાવિનોદો તથા શાસ્ત્રીય વાદવિવાદો ત્યાં થતા. શ્વેતાંબર આચાર્ય વાદી દેવસૂરિ અને દિગંબર આચાર્ય કુમુદચંદ્ર વચ્ચે થયેલા વાદનું નિરૂપણ સમકાલીન કવિ યશશ્ચંદ્રે 'મુદ્રિતકુમુદચન્દ્ર પ્રકરણ' નામે નાટકમાં કર્યું છે. આ વાદનું અધ્યક્ષસ્થાન સિદ્ધરાજે સ્વીકાર્યું હતું. સિદ્ધરાજને વિદ્યાનાં કાર્યોમાં અંગત અને ઊંડો રસ હતો એ નિઃસંદેહ છે. દેવગિરિના રાજા કૃષ્ણ (ઈ.સ. ૧૨૪૭-૧૨૬૦)ના આરોહક—હસ્તિદળના ઉપરી જહ્લણકૃત સુભાષિત સંગ્રહ 'સૂક્તિમુક્તાવલિ'માં શરદવર્ણનમાં સિદ્ધરાજકૃત બે સુભાષિતો ઉદ્ધૃત થયાં છે (પૃ. ૨૨૭-૨૮) અને એની નીચે **सिद्धचक्रवर्तिनो जयसिंहदेवस्यैतौ** એવી સ્પષ્ટ નોંધ સંગ્રહકારે મૂકી છે. ગુજરાતના ચૌલુક્યયુગીન બીજા સંસ્કૃત કવિઓ હેમચન્દ્ર, સોમપ્રભ, શ્રીપાલ, વસ્તુપાલ, સોમેશ્વર, વાગ્ભટ, વિજયપાલ, પ્રહ્લાદન, દેવબોધિ, અથવા દેવબોધ, કુમુદચન્દ્ર, અરિસિંહ વગેરેના શ્લોકો પણ 'સૂક્તિમુક્તાવલિ'માં છે, એ સન્દર્ભમાં આ વસ્તુ અવલોકવાની છે. દેવગિરિ અને ગુજરાતના રાજાઓ વચ્ચે પણ સતત યુદ્ધો ચાલ્યા કરતાં હતાં, પણ આ સંઘર્ષને પરિણામે વચ્ચે વચ્ચે શાન્તિના ગાળામાં સંપર્કો વધતા હશે અને બંને પક્ષે આદાન-પ્રદાન થતું હશે એમ આ ઉપરથી જણાય છે.

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મૂલરાજના પુત્ર દુર્લભરાજે પાટણમાં દુર્લભરાજસર અથવા દુર્લભસરોવર નામે એક સરોવર બંધાવ્યું હતું. એનો વિશાળ પાયા ઉપર જીર્ણોદ્ધાર કરી, સરસ્વતીનું વહેણ એમાં વાળીને તથા એના તટ ઉપર એક હજાર શિવલિંગ સ્થાપીને સિદ્ધરાજે એને ભવ્ય બનાવ્યું હતું અને એને સહસ્રલિંગ સરોવર નામ આપ્યું હતું. સિદ્ધરાજના નામથી એ સિદ્ધસર તરીકે પણ ઓળખાતું. દટાઈ ગયેલા એ સરોવરના ભવ્ય અવશેષો થોડાંક વર્ષ ઉપર ખોદી કાઢવામાં આવ્યા છે. એના કિનારે, માલવવિજયના સ્મારકરૂપે સફેદ આરસનો કીર્તિસ્તંભ બાંધવામાં આવ્યો હતો અને એમાં સહસ્રલિંગનું સુદીર્ઘ પ્રશસ્તિકાવ્ય, જે પ્રજ્ઞાચક્ષુ રાજકવિ શ્રીપાલે રચ્યું હતું તે કોતરીને મૂકવામાં આવ્યું હતું. સહસ્રલિંગની સાથે આ કીર્તિસ્તંભ અને પ્રશસ્તિ પણ નાશ પામ્યાં છે, પણ એમાંના શ્લોકો પ્રબન્ધોમાં ક્યાંક ક્યાંક ઉદ્ધૃત થયેલા છે તથા પ્રશસ્તિવાળી પટ્ટિકાનો એક ટુકડો પાટણમાં વીજળકૂવા નામે ઓળખાતા લત્તામાં મહાદેવની દહેરીની ભીંતમાં ચણાયેલો મળી આવ્યો છે.

વિદ્યાધામ અવન્તિનો તથા તેના કેન્દ્રરૂપ સરસ્વતીસદનનો કંઈક આદર્શ ચિત્તમાં રાખીને સિદ્ધરાજે પાટણમાં સહસ્રલિંગ સરોવરની આસપાસ વિવિધ વિદ્યાઓનું શિક્ષણ આપતા વિદ્યામઠો સ્થાપ્યા હતા અને તીરપ્રદેશનાં દેવમન્દિરોમાં સામાન્ય પ્રજાવર્ગમાં પણ સંસ્કાર-વિતરણ થાય એવી વ્યવસ્થા કરી હતી. સહસ્રલિંગ એ નાગરિકોનું પૂજાસ્થાન, વિદ્યાસ્થાન અને મનોવિનોદસ્થાન બન્યું હતું. સંસ્કૃત ‘દ્વયાશ્રય’ કાવ્યના પંદરમા સર્ગમાંથી આચાર્ય હેમચન્દ્રના શબ્દો એ વિષે જોઈએ :

> अतीत्य मैथिलं युद्धं राघवो नु कृतक्रतुः ।
> प्रापातेतरतिथ्यां स पूर्तं चक्रे महासरः ॥ ११४ ॥

મૈથિલીને કારણે થયેલું યુદ્ધ પૂરું કરીને જેમ રાઘવે યજ્ઞ કર્યો હતો તેમ તે રાજાએ (સિદ્ધરાજે) વ્યતિપાતરહિત શુભ તિથિએ એ પૂર્ત મહાસરોવર કરાવ્યું.

> पापकाककुलश्यैनंपातायां तत्तटीभुवि ।
> सत्रशाला नृपश्चक्रे तैलंपातक्रियाजुषम् ॥ ११५ ॥

પાપરૂપી કાકસમૂહને માટે બાજરૂપ એવા એના તટપ્રદેશ ઉપર, (અગ્નિમાં) તિલપાત આદિ ક્રિયાઓ જેમાં થાય છે એવી સત્રશાલાઓ તે રાજાએ કરાવી.

> पादां मिथोंह्रिसंघट्टैः स्मरन्ति सहढौकिनः ।
> तासु छान्दसनैमित्तमौहूर्त्ता भोज्यलिप्सवः ॥ ११६ ॥

વેદ, નિમિત્તશાસ્ત્ર અને જ્યોતિષશાસ્ત્રનું અધ્યયન કરનારા ભોજનાર્થીઓ એકસાથે આગળ જતાં, પરસ્પરના પગની અથડાઅથડીમાં, પગે પગ કચરાય એવી રમતને સંભારે છે.

> आग्निष्टोमिकयावक्रीतिकवासवदत्तिकैः ।
> दशावतारीं प्रकृतव्याख्यामत्र व्यधत्त सः ॥ ११९ ॥

અગ્નિષ્ટોમિક—અગ્નિષ્ટોમ (સોમયાગ) કરનારા, યવક્રય (સોમયાગમાં કરાતી ઇષ્ટિ, જેમાં યવક્રય, સોમક્રય વગેરેનાં વિધાનો છે.) કરનારા તથા વાસવદત્તિક--વાસવદત્તા વગેરે સંસ્કૃત

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સાહિત્યની પ્રસિદ્ધ કથાઓ જાણનારા વિદ્વાનો* જ્યાં પ્રવચન કરે છે એવી દશાવતારી (દશાવતારની પ્રતિમા સહિત મન્દિર) રાજાએ ત્યાં કરાવી.

स वार्त्तिसूत्रिकान्काल्पसूत्रानागमविधिकान् ।
सांसर्गविद्यांस्त्रैविद्यानाङ्गविद्यांश्च कोविदान् ॥ १२० ॥

क्षात्रविद्यान्धार्मविद्याँल्लौकायितकविद्विषः ।
याज्ञिकानौक्थिकांश्चात्र चक्रे प्रीणयितुं मठान् ॥१२१॥

વૃત્તિ અને સૂત્રને જાણનારા, કલ્પસૂત્ર જાણનારા અને આગમવિદ, સંસર્ગવિદ્યા--ઔષધ-સંપર્કવિદ્યા જાણનારા, ત્રૈવિદ્યો--વેદવિદ્યાનાં રહસ્યો જાણનારા, અંગવિદ્યા (વેદનાં છ અંગોની વિદ્યા અથવા શરીરલક્ષણશાસ્ત્ર)ના જ્ઞાતાઓ, ક્ષાત્રવિદ્યા--ધનુર્વેદ અને શસ્ત્રવિદ્યા જાણનારા, ધર્મશાસ્ત્રના નિષ્ણાતો, લોકાયતો--ચાર્વાક દર્શનના અનુયાયીઓનો દ્વેષ કરનાર--પરાજય કરનાર, યાજ્ઞિકો, ઔક્થિકો (ઉક્થ વગેરે શ્રૌતયાગ કરાવનાર) આદિ કોવિદોને પ્રસન્ન કરવા માટે તેણે અનેક મઠો બાંધ્યા.

अनुब्राह्मण्याढ्यैः सशतपथिकैः षष्टिपथिकैः
कृताध्यायान्याशूत्तरपदिकयुक्पूर्वपदिकैः ।
द्विषद्भूवाक्येभ्यः पदिक इव निर्धार्य स पदा-
न्युरून् कीर्तिस्तम्भानिव सुरगृहाणि व्यरचयत् ॥ १२२ ॥

બ્રાહ્મણ ગ્રન્થોમાં નિપુણ, શતપથિક (શતપથ બ્રાહ્મણના સોયે પથ--અધ્યાય જાણનાર), ષષ્ટિ પથિક (એમાંના સાઠ અધ્યાય જાણનાર), ઉત્તરપદ--પૂર્વપદના વિવેકપૂર્વક એનાં લક્ષણ સમજનાર વિદ્વાનો જ્યાં અધ્યયન કરી રહ્યા છે એવાં, પોતાના કીર્તિસ્તંભ જેવાં સુરગૃહો, (વૈયાકરણ વાકયમાંથી પદ અર્થાત્ શબ્દ પકડે તેમ) શત્રુભૂમિમાં પદિક બનીને--પગ મૂકીને તે રાજાએ કરાવ્યાં.

ગુજરાતના પાટનગરના હૃદયભાગમાં આવેલું સહસ્રલિંગ એક સૌંદર્યધામ પણ હતું એવી કલ્પના અત્યારના એના અવશેષો ઉપરથી તથા શ્રી. રામલાલ મોદીએ 'સરસ્વતીપુરાણ'ને આધારે તૈયાર કરાવેલા એના નકશા ઉપરથી થાય છે. એની આસપાસના ધબકતા સાંસ્કારિક જીવનનો ખ્યાલ જેમ 'દ્વયાશ્રય'માંથી તથા એ પછી રચાયેલા પ્રબન્ધાત્મક વિવિધ સાહિત્યમાંથી આવે છે તેમ સહસ્રલિંગ અને સરસ્વતીના તીરપ્રદેશનાં તીર્થો અને ત્યાંના ધાર્મિક જીવનની ઝાંખી 'સરસ્વતીપુરાણ'માંથી થાય છે.

સિદ્ધરાજના ઉત્તરાધિકારી કુમારપાલના સમયમાં ગુર્જર ભૂમિની અને પાટણની ઉન્નતિ પરાકાષ્ટાએ પહોંચી. કુમારપાલ ઉપર આચાર્ય હેમચન્દ્રના ઉપદેશોની ઊંડી અસર થઈ હતી; પોતાના કુલક્રમાગત શૈવ ધર્મનું અનુસરણ ચાલુ રાખવા છતાં તેણે શ્રાવકનાં વ્રતોનો સ્વીકાર કર્યો હતો.

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*'દ્વયાશ્રય'ના ટીકાકાર અભયતિલકગણિએ ગોવિન્દ નામે ગ્રન્થિકનો અહીં ઉલ્લેખ કર્યો છે. ગોવિન્દ એ સમયનો પ્રસિદ્ધ ગ્રન્થિક–કથાગ્રન્થો ઉપરથી પ્રવચન કરનાર હોવો જોઈએ. મહારાષ્ટ્રના ગોવિન્દ નામે નિપુણ પ્રવચનકારે આશાપલ્લીના લોકોને મુગ્ધ કરી દીધા હતા એનું કથાનક 'પુરાતનપ્રબંધસંગ્રહ'માં છે ('સંશોધનની કેડી', પૃ. ૧૩૩).

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એક અનુશ્રુતિ પ્રમાણે, કુમારપાલ લોભી અને કંજૂસ હતો. 'પ્રબંધચિન્તામણિ' એક કથાનક નોંધે છે કે સોલાક નામે સંગીતકારની ગીતકલાથી પ્રસન્ન થયેલા રાજા કુમારપાલે તેને પ્રીતિદાન તરીકે ૧૧૬ દ્રમ્મ આપ્યા હતા; પણ એમાંથી સોલાકે મિષ્ટાન્ન ભોજન કર્યું અને બાળકોને મીઠાઈ વહેંચી ખુશી કર્યાં, તેથી ક્રોધાયમાન થયેલા રાજાએ તેને નિર્વાસિત કર્યો. રાજ્યપ્રાપ્તિ પહેલાં કુમારપાલને કંગાલ અવસ્થામાં વર્ષો સુધી જે રઝળપાટ કરવો પડેલો એની કંઈક માઠી અસર એના વ્યકિતત્વ ઉપર રહી ગઈ હોય એ સંભવિત છે. 'ગણદર્પણ' નામે વ્યાકરણના ગ્રન્થનું તથા ૩૩ શ્લોકના જૈન સ્તોત્રનું કર્તૃત્વ કુમારપાલના નામે ચઢેલું છે. આ રચનાઓનું કર્તૃત્વ ખરેખર કુમારપાલનું હોય કે કેમ એ પ્રશ્ન રહે છે, પણ 'ગણદર્પણ'ની રચના કુમારપાલના દંડનાયક વોસરિ અને પ્રતીહાર ભોજદેવના અધ્યયન માટે થયેલી હોઈ એ કૃતિ વસ્તુતઃ કોઈ સભાપંડિતની હોય તો પણ કુમારપાલની વિદ્યાપ્રીતિ એમાંથી સ્પષ્ટ વરતાય છે.

પાટણ પાસે કુમારપાલે કુમરગિરિ નામે ઓળખાતું જૈન મન્દિર બાંધ્યું હોવાની અનુશ્રુતિ છે; પાટણથી નૈઋર્ત્યે ચારેક માઈલ દૂર આવેલા કુણઘેર ગામના નામમાં એ કેવલ નામશેષ રહ્યું છે. 'દ્વયાશ્રય' મહાકાવ્ય (સર્ગ ૨૦) અનુસાર, કુમારપાલે મંત્રી વાગ્ભટને આજ્ઞા કરીને સોમનાથના મન્દિરનો તથા તેની પાસેના કેદારેશ્વરના મન્દિરનો જીર્ણોદ્ધાર કરાવ્યો, અણહિલ પાટણમાં કુમારપાલેશ્વરનું મન્દિર કરાવ્યું તથા પાટણ અને દેવપત્તન—પ્રભાસ પાટણ—માં પાર્શ્વનાથનાં મન્દિરો બંધાવ્યાં.

પાટણમાં કુમારપાલે બાંધેલું પાર્શ્વનાથનું મન્દિર કુમારવિહાર તરીકે ઓળખાયું. એ મન્દિર જેટલું ભવ્ય તેટલું જ કલામય હોવું જોઈએ. એનું કવિત્વમય અને વિગતભરપૂર વર્ણન આચાર્ય હેમચન્દ્રના શિષ્ય રામચન્દ્રે 'કુમારવિહાર શતક' નામના શતશ્લોકી કાવ્યમાં કર્યું છે. (આ કાવ્યના એવા જ સુન્દર પરિચય માટે જુઓ 'કુમાર' માસિકના ૨૦૦મા અંકમાં શ્રી. રસિકલાલ છો. પરીખનો લેખ 'કુમારવિહાર'.) પ્રાચીન સમયમાં મન્દિરોનું સમાજજીવનમાં કેવું રસ અને ઉલ્લાસથી ભરેલું સ્થાન હતું એનો ખ્યાલ એ કાવ્ય ઉપરથી આવે છે. કુમાર-વિહારની 'આલેખ્યસભા' અર્થાત્ ચિત્રશાલાનું વર્ણન એમાં છે. રામચન્દ્ર કહે છે કે "એક ચિત્રસંસદ જ વિવિધ પ્રકારના લોકોને વારંવાર તરલ કરવાને બસ છે." કુમારવિહારનાં ભિત્તિચિત્રોમાં સમુદ્રમંથનમાંથી નીકળેલાં રત્નો, તોફાની હાથીઓ, ઊંટ (અથવા ઊંટરથ અને વાનરરથ?), દેવતાઓનાં ચરિત્રો, વિવિધ પ્રકારનાં નાટયો, સંગ્રામો આદિનું નિરૂપણ હતું એમ વર્ણન ઉપરથી સમજાય છે. ગુજરાતનાં વિલુપ્ત ભિત્તિચિત્રોના આ વિગતવાર ઉલ્લેખો વિક્રમના તેરમા સૈકાના આરંભમાં એટલે કે ઈસવી સનના બારમા સૈકાના મધ્યભાગના છે. ગુજરાતની ગ્રન્થસ્થ ચિત્રકલાના વિરલ નમૂનાઓ આજે એની યે પહેલાંના મળે છે. 'ગુજરાતની ચિત્રકલા', 'પશ્ચિમ ભારતની ચિત્રકલા', 'ગુજરાતની જૈનાશ્રિત ચિત્રકલા' એવાં વિવિધ નામે એને ઓળખવામાં આવે છે. ગુજરાતનાં સૌથી જૂનાં, ઉપલબ્ધ ચિત્રો, જૈન હસ્તલિખિત પુસ્તકભંડારમાં સચવાયેલી હસ્તપ્રતોમાં છે. પણ એને જૈન કલા કહેવા કરતાં આ પ્રદેશમાં જે કલા-પરિપાટી પ્રચલિત થઈ હતી એના નમૂના ગણવા એ ઉચિત છે.

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પંદરમાં સૈકા પહેલાનાં ગ્રન્થસ્થ ચિત્રો પૂર્વ ભારતમાં બૌદ્ધોનાં અને પશ્ચિમ ભારતમાં જૈનોનાં છે. બંનેનો ઈતિહાસ એકસરખો પ્રાચીન હશે, પણ ઉપલબ્ધ બૌદ્ધ નમૂનાઓ પ્રમાણમાં પ્રાચીનતર છે અને ઈસવી સનના દસમા સૈકાથી મળવા શરૂ થાય છે. ઉત્તર બંગાળ અને નેપાલમાંથી બૌદ્ધ ચિત્રોની ધાટી તિબેટ ગઈ, જ્યાં તેનું સ્વરૂપાન્તરે સાતત્ય ઠેઠ આધુનિક સમય સુધી રહ્યું હતું. ગુજરાતી ચિત્રકલામાં ચૌદમો–પંદરમો સૈકો શ્રેષ્ઠ છે. આખાયે ચિત્રસંપ્રદાયનાં સર્વોત્તમ રેખાંકનો—'ડ્રૉઇંગ' એ સમયનાં છે. લઘુચિત્રોમાં રેખાનું મહત્ત્વ સૌથી વધારે છે. વામનકૃત 'કાવ્યાલંકારસૂત્ર વૃત્તિ'માં કહ્યું છે—

> यथा विच्छिद्यते रेखा चतुरं चित्रपण्डितैः ।
> तथैव वागपि प्राज्ञैः समस्तगुणगुम्फिता ॥ (३–१–२५)

અને આ રેખાંકનો પણ લખાતા અક્ષરની જેમ ઝડપથી થયેલાં છે એમ આ વિષયના તજ્જ્ઞોનું અનુમાન છે.

આઠમા સૈકાથી અજંટાની ચિત્રકલા લુપ્ત થઈ લાગે છે; પણ વસ્તુતઃ એનું સાતત્ય પશ્ચિમ ભારતની—અને તેમાંયે મારુ–ગુર્જર કલામાં હોવું જોઈએ એવા તર્ક માટેનાં પ્રમાણો છે. આઠમા સૈકામાં વનરાજે પાટણમાં પંચાસરા પાર્શ્વનાથનું મન્દિર બાંધ્યું અને ત્યાર પછી અનેક સ્થાપત્યો થયાં એમાંનાં કોઈ ભિત્તિચિત્રો આજે જોવા મળે એમ નથી. બારમાથી ઓગણીસમા સૈકા સુધીના ગુજરાતી ચિત્રકલાના પુષ્કળ નમૂનાઓ હવે પ્રાપ્ત થયા છે, અને સર્વશ્રી નાનાલાલ ચમનલાલ મહેતા, નોર્મન બ્રાઉન, મુનિશ્રી પુણ્યવિજયજી, સારાભાઈ નવાબ, મંજુલાલ મજમુદાર, ઉમાકાન્ત શાહ, મોતીચંદ્ર વગેરે અભ્યાસીઓએ એમાંના ઘણા પ્રગટ કર્યા છે. નવમા સૈકાથી અગિયારમા સૈકા સુધીની ત્રણ શતાબ્દીઓ ચિત્રકલાની દૃષ્ટિએ ખાલી હશે એમ તો કેમ કહેવાય? એમ હોવું સંભવિત પણ નથી. બારમા સૈકાનાં તાડપત્રનાં ચિત્રોમાં પણ એવી રૂઢ અને પાકી શૈલી છે કે એની પાછળ સદીઓની માનાસ્પદ પરંપરા હોવી જોઈએ એમ શ્રી. રવિશંકર રાવળ જેવા ચિત્રકાર અને કલાકોવિદનું માનવું છે. આ સ્વતંત્ર ચિત્રો નથી, 'બુક-ઇલસ્ટ્રેશન્સ' છે. પણ વાઙ્મય સાથે ચિત્રકલા કેવો તાલ મેળવે છે એ દર્શાવવામાં આ શૈલીએ અવધિ કરી છે. છૂટાં ચિત્રામણો, કાપડ ઉપરનાં ચિત્રપટો, લાકડાની પાટલીઓ ઉપરનાં ચિત્રો, સાદાં અને ભરતવાળાં પૂંઠિયાં વગેરે ઉપરથી જણાય છે કે આ કલા માત્ર શ્રીમાનો માટે નહોતી, પણ વ્યાપક પ્રજાજીવનમાં એનું સ્થાન નિશ્ચિત થઈ ચૂક્યું હતું.

ગુજરાતમાંથી મળેલી તાડપત્રની સૌથી જૂની સચિત્ર હસ્તપ્રત પાટણના સંઘવીના પાડાના ગ્રન્થભંડારમાંથી મળેલી સં. ૧૧૫૭માં લખાયેલી 'નિશીથચૂર્ણિ' છે. કાલાનુક્રમે બીજી સચિત્ર પોથી ખંભાતમાં શાન્તિનાથના ભંડારમાંની, સં. ૧૧૮૪માં લખાયેલી 'જ્ઞાતાધર્મકથા'ની છે. આ બંને જૈન આગમગ્રન્થો છે અને બંનેની નકલો સિદ્ધરાજ જયસિંહના રાજ્યકાલમાં થયેલી છે. જેસલમેરની લાકડાની પાટીઓ ઉપર દેવસૂરિ અને કુમુદચંદ્રના વાદ પ્રસંગનાં ઉત્કૃષ્ટ ચિત્રો છે તે સમસામયિક એટલે કે સિદ્ધરાજના સમયનાં જ છે એમ અભ્યાસીઓનું માનવું છે.

કુમારપાલના રાજ્યના આરંભકાળની સં. ૧૨૦૦માં લખાયેલી, ખંભાત ભંડારમાંની 'દશવૈકાલિક' લઘુવૃત્તિની તાડપત્રીય પ્રતને અંતે આચાર્ય હેમચન્દ્ર, તેમના શિષ્ય મહેન્દ્રસૂરિ

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અને રાજા કુમારપાલનાં ચિત્રો છે. આ ત્રણેય વ્યક્તિવિશેષોના જીવનકાળનાં આ ચિત્રો હોઈ એનું અપૂર્વ ઐતિહાસિક મહત્ત્વ છે. જોકે એમાં ખરેખર વ્યક્તિસામ્ય કેટલું હશે એ પ્રશ્ન રહે છે ખરો. 'ત્રિષષ્ટિશલાકાપુરુષચરિત' અંતર્ગત 'મહાવીરચરિત'ની સં. ૧૨૯૪માં લખાયેલી પાટણની પોથીમાં પણ હેમચન્દ્ર અને કુમારપાલનાં ચિત્ર છે. 'સિદ્ધહેમ વ્યાકરણ'ની લેખન સંવત વિનાની પાટણની એક તાડપત્રીય હસ્તપ્રતમાં, હેમચન્દ્રને સિદ્ધરાજ જયસિંહ વ્યાકરણ રચવાને પ્રાર્થના કરે છે તથા વ્યાકરણ રચાયા પછી સિદ્ધરાજ સમક્ષ રજૂ કરવામાં આવે છે અને હાથી ઉપર સ્થાપના કરી નગરમાં સત્કારપૂર્વક એને ફેરવવામાં આવે છે એ પ્રસંગનાં સુન્દર ચિત્રો છે. હસ્તપ્રતમાં લેખન સંવત નથી, પણ લિપિ ઉપરથી 'સિદ્ધહેમ વ્યાકરણ'ની રચના પછી ટૂંક સમયમાં જ એની આ નકલ થઈ હોવાનું માનવામાં આવે છે. એમ હોય તો, સિદ્ધરાજનું આ વ્યક્તિચિત્ર એના જીવનકાળનું જ ગણાય. વાઘેલા રાજ્યકાળના અંત પહેલાં લખાયેલી, લેખન વર્ષના સ્પષ્ટ ઉલ્લેખવાળી, નિદાન દસેક સચિત્ર હસ્તપ્રતો તો આજે વિદ્યમાન છે જ. આ સિવાય બીજી કેટલીક સચિત્ર પ્રતો એવી પણ છે જેમાં લેખન વર્ષ નથી, પણ લિપિ અને ચિત્રધાટીને આધારે જેમને એ જ સમયમાં મૂકી શકાય.

આ ચિત્રકલામાં માત્ર ધાર્મિક વિષયો છે એમ નથી, મોટા ભાગની ઉપલબ્ધ હસ્તપ્રતો જૈન ધાર્મિક ગ્રન્થોની હોઈ એમાં એ પ્રકારનાં ચિત્રોનું બાહુલ્ય છે એટલું જ. વાઘેલા રાજ્યના અંત પછી માત્ર ૯૨ વર્ષે, સં. ૧૫૦૮ (ઈ. સ. ૧૪૫૨)માં લખાયેલા ગુજરાતી ફાગુ કાવ્ય 'વસંતવિલાસ'ના સચિત્ર ઓળિયામાં એ જ ઘુંટાયેલી શૈલીનાં ઉત્કૃષ્ટ અને બહુસંખ્ય સાંસારિક ચિત્રો છે એ બતાવે છે કે આ ચિત્રશૈલી સાંપ્રદાયિક નહિ, પણ સાર્વજનીન હતી.

કુમારવિહારની 'આલેખસભા'ની વાત કરતાં આ થોડુંક વિષયાન્તર થયું. ફરી વાર ઈતિહાસની આનુપૂર્વીને અનુસરીએ. સં. ૧૨૨૯(ઈ. સ. ૧૧૭૩)માં કુમારપાલનું અવસાન થયું. અને તે અપુત્ર હોવાથી એના ભાઈ મહીપાલનો પુત્ર અજયપાલ ગુજરાતની ગાદીએ આવ્યો. ગુજરાતના રાજાની ઊતરતી કળા ત્યારથી શરૂ થઈ જણાય છે. અજયપાલે માત્ર ત્રણ વર્ષ રાજ્ય કર્યું. એના એક પ્રતીહારે એનો વધ કર્યો હતો. અજયપાલના પુત્ર મૂલરાજ અથવા બાળ મૂલરાજે પણ માત્ર બે વર્ષ રાજ્ય કર્યું અને એના પછી એનો ભાઈ ભીમદેવ બીજો અથવા ભોળો ભીમ બાળક વયે સં. ૧૨૩૪(ઈ. સ. ૧૧૭૮)માં ગાદીએ બેઠો અને તેણે સં. ૧૨૯૮ (ઈ. સ. ૧૨૪૨) સુધી ૬૪ વર્ષનું લાંબું રાજ્ય ભોગવ્યું. સમ્રાટની બાલ્યાવસ્થા અને બીજાં અનેક રાજકીય કારણોસર પાટણની કેન્દ્રીય સત્તા શિથિલ થઈ હતી અને જયંતસિંહ નામે કોઈ એક સામંત ભીમદેવને પદચ્યુત કરી કેટલોક સમય પાટણનો મહારાજાધિરાજ થઈ ગયો હતો અને તેણે પોતાનાં તામ્રપત્ર પણ બહાર પાડયાં હતાં. એ સમયે ધોળકાના વાઘેલા રાણાઓ લવણપ્રસાદ અને વીરધવલ તથા એમના મંત્રીઓ વસ્તુપાલ અને તેજપાલની સહાય ભીમદેવને મળી ન હોત તો આંતરિક ખટપટોને કારણે સોલંકીઓનું રાજ્ય ઘણું વહેલું નાશ પામ્યું હોત. સમકાલીન રાજપુરોહિત અને કવિ સોમેશ્વર પોતાના 'કીર્તિકૌમુદી' કાવ્યમાં કહે છે તે પ્રમાણે—

> मन्त्रिभिर्माण्डलीकैश्च बलवद्भिः शनैः शनैः ।
> बालस्य भूमिपालस्य तस्य राज्यं व्यभज्यत ॥ (સર્ગ ૨, શ્લોક ૬૧)

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અર્થાત્ બળવાન મંત્રીઓ અને માંડલિકોએ ધીરે ધીરે એ 'બાલભૂમિપાલ'નું અથવા બાળકરાજા ભીમદેવનું રાજ્ય વહેંચી લીધું.

વળી એ જ વાત શબ્દાન્તરે ગુર્જર રાજ્યલક્ષ્મીના મુખમાં સોમેશ્વરે મૂકી છે—

यो वर्तते सम्प्रति चक्रवर्तिपदेऽत्र बालः स बलान्यरीणाम् ।
क्षमः समग्राणि न निग्रहीतुं दीपस्तमांसीव तटस्थितानि ॥
ये मन्त्रिणो येऽत्र च मण्डलीकास्तेषु क्रमो नास्ति पराक्रमोऽस्ति ।
प्रतिक्रिया काऽस्तु ततोऽस्ति येषां कामो मयि स्वामिपरिग्रहेऽपि ॥

(સર્ગ ૨, શ્લોક ૯૪-૯૫)

અર્થાત્ જે બાલ (ભીમદેવ) હાલ ચક્રવર્તીપદે છે તે શત્રુઓનાં સમગ્ર સૈન્યોને ખાળવાને સમર્થ નથી—જેમ (પ્રવાહમાં તરતો) એક દીવો તટ ઉપરના અંધકારને ખાળવા સમર્થ નથી. અહીં જે મંત્રીઓ અને માંડલિકો છે તેમનામાં કોઈ (વ્યવસ્થા) ક્રમ નથી. કેવળ પરાક્રમ છે; હું કે જે તેમના સ્વામીની પત્ની છું એની પણ જેઓ કામના કરે એનો પછી શો પ્રતિકાર થાય?

પરન્તુ ધોળકાના રાણાઓ અને વસ્તુપાલ તેજપાલના પ્રયત્નોથી પાટણની કેન્દ્રીય સત્તા ફરી વાર સુસ્થાપિત થઈ અને એક રીતે કહીએ તો, સિદ્ધરાજ અને કુમારપાલના સમયની જાહોજલાલી પુનઃ દૃશ્યમાન થઈ. વસ્તુપાલ-તેજપાલના યુગમાં હિન્દુ ગુજરાતનું છેલ્લું રાજકીય અને સાંસ્કારિક પુનરુજ્જીવન થયું. વસ્તુપાલ માત્ર કુશળ રાજપુરુષ કે યોદ્ધો નહોતો, પણ વિદ્યા અને કલાનો ઉપાસક હતો એટલું જ નહિ, તે પોતે પણ સંસ્કૃત ભાષાનો એક સારો કવિ હતો. 'નરનારાયણાનંદ' નામે એક સંસ્કૃત મહાકાવ્ય તથા કેટલાંક સ્તોત્રો વસ્તુપાલે રચેલાં છે. આબુ અને ગિરનાર ઉપરનાં મન્દિરો એના તથા તેજપાલના અદ્ભુત કલાપ્રેમની સાક્ષી પૂરે છે; વસ્તુપાલનાં બીજાં અનેક સ્થાપત્યોનાં વર્ણન, ઉલ્લેખ કે નોંધ જૂના ગ્રન્થોમાં મળે છે.

પણ આજે એ બધાં વિદ્યમાન નથી. વસ્તુપાલે મોટી રકમ ખર્ચીને અણહિલવાડ, ખંભાત અને ભરૂચમાં ગ્રન્થભંડારો સ્થાપ્યા હતા, પણ અસંદિગ્ધ રીતે એ ભંડારોમાંની ગણી શકાય એવી માત્ર બે હસ્તપ્રતો હજી સુધી જાણવામાં આવી છે—શ્રી. ચન્દ્રસૂરિકૃત 'જીતકલ્પ-ચૂર્ણિ વ્યાખ્યા'ની સં. ૧૨૮૪(ઈ.સ. ૧૨૨૮)માં લખાયેલી પાટણભંડારમાંની પ્રત અને વસ્તુપાલના પોતાના હસ્તાક્ષરોમાં સં. ૧૨૯૦(ઈ.સ. ૧૨૩૪)માં લખાયેલી ઉદયપ્રભસૂરિકૃત 'ધર્માભ્યુદય મહાકાવ્ય'ની ખંભાતમાં સચવાયેલી પ્રત.

વસ્તુપાલના અમાત્યપદ દરમિયાન પુનર્વ્યવસ્થિત થયેલું ગુજરાતના રાજ્યનું તંત્ર ભીમદેવના પુત્ર ત્રિભુવનપાલના બે વર્ષના ટૂંકા શાસનમાં તેમ જ એ પછી ધોળકાના રાણકપદેથી ગુજરાતના મહારાજાધિરાજપદે આરૂઢ થયેલા વાઘેલા વીસલદેવ, એના ભત્રીજા અર્જુનદેવ તથા અર્જુનદેવના પુત્ર સારંગદેવના સમય સુધી—સં. ૧૩૫૪ (ઈ.સ. ૧૨૯૮) સુધી નિષ્કંટક ચાલુ રહ્યું હતું. એ તંત્ર સં. ૧૨૯૬(ઈ.સ. ૧૨૪૦)માં વસ્તુપાલના અવસાન પછી છ દાયકા સુધી લગભગ પૂર્વવત્ કાર્યક્ષમતા જાળવી રહ્યું હતું અને એના રક્ષણ નીચે પ્રજાજીવનનું સાતત્ય બરોબર સચવાયું હતું. છેલ્લા વાઘેલા રાજા કર્ણદેવના અવિચારીપણાને પરિણામે માધવ

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મંત્રીએ અલાઉદ્દીન ખિલજીને ગુજરાત ઉપર આક્રમણ કરવા નિમંત્રણ આપ્યું ન હોત તથા અહીંની સૈન્યવ્યવસ્થા, રાજ્યવ્યવસ્થા અને સમાજવ્યવસ્થાનાં મર્મસ્થાનો આક્રમણકારને બતાવ્યાં ન હોત તો સોલંકી ગુજરાતની રાજકીય જીવનશક્તિનો ક્ષય અર્ધીક શતાબ્દી સુધી તો ન થયો હોત એમ એકંદર પરિસ્થિતિનો વિચાર કરતાં લાગે છે. અલબત્ત, ઈતિહાસચર્ચામાં સાંકેતિક (Hypothetical) વિધાનોનો ઝાઝો અર્થ નથી એ સ્વીકારવું જ જોઈએ.

"ભારતના ઈતિહાસમાં ગુપ્ત રાજ્યકાળને સુવર્ણયુગ કહે છે તેમ ગુજરાતના ઈતિહાસમાં સોલંકી રાજ્યકાળને સુવર્ણયુગ કહેવાની પ્રથા પડી છે. 'સુવર્ણયુગ' એક આલંકારિક શબ્દપ્રયોગ છે, જેમાંથી બુદ્ધિગમ્ય સ્પષ્ટ અર્થાભિવ્યક્તિ થતી નથી; પણ જે યુગમાં રાજા અને પ્રજાની શ્રદ્ધા અને સિદ્ધિ વિશિષ્ટ હોય તથા જીવનનાં વિવિધ ક્ષેત્રે તેમણે ઉત્સાહપૂર્વક પુરુષાર્થ કરીને સમાજજીવનને કંઈક અર્થપૂર્ણ બનાવ્યું હોય એ યુગ ઈતિહાસમાં વિશિષ્ટ ગણાવો જોઈએ. આ રીતે સોલંકી યુગ ગુજરાતની જાણવામાં આવેલી તવારીખમાં એક પ્રકારના ચાવીરૂપ સ્થાને છે. ભૌતિક દૃષ્ટિએ તો એ જમાનો આજના કરતાં ઘણો પછાત હતો. સામંતશાહી દમન નહોતું અથવા પ્રજાનું આર્થિક જીવન બહુ સલામત હતું એમ પણ નહિ કહી શકાય. પરંતુ મહત્ત્વની વાત એ છે કે એકંદર પ્રજાને પોતાના રાષ્ટ્રના ગૌરવનો ભલે અસ્પષ્ટરૂપે પણ ખ્યાલ હતો, પોતાના પરાક્રમનું અભિમાન હતું, કોઈ ઉચ્ચ અભિલાષો અને આદર્શોને મૂર્તિમંત કરવામાં પોતે નિમિત્ત બની રહી છે એવી સભાનતા હતી અને ઉચ્ચતર સિદ્ધિઓ માટેનો ઉત્સાહ હતો એ વાતનું સ્પષ્ટ પ્રતિબિંબ સોલંકી યુગમાં સંસ્કૃત, પ્રાકૃત અને તત્કાલીન દેશભાષામાં રચાયેલા વિપુલ સાહિત્યમાં પડેલું છે. સોલંકી યુગનું મહત્ત્વ એ ભાવનાઓમાં છે. સાહિત્ય, શિલ્પ અને સ્થાપત્યમાં તે સમયે રચાયેલાં ભવ્ય સ્મારકોમાં એ ભાવનાઓનો જ આવિષ્કાર છે." ('ઈતિહાસ અને સાહિત્ય', પૃ. ૩૪.)

સોલંકી યુગના વારસામાંથી અર્વાચીન ગુજરાત અનેક રીતે બોધ અને પ્રેરણા લઈ શકે તથા એ વારસાને વિસ્તારી અને વિકસાવી શકે.

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ભારતીય ઇતિહાસના કહેવાતા અંધકારયુગો

(લેખાંક ત્રીજો)*

જશુ બી. પટેલ
અધ્યક્ષ, ઇતિહાસવિભાગ
શ્રી સ્વામિનારાયણ આર્ટ્સ કૉલેજ, અમદાવાદ

વાકાટક યુગ ૧—સાધનસામગ્રી

અંધકારયુગ એટલે શું?

ભારતીય ઇતિહાસમાં કમનસીબે કેટલાક કહેવાતા અંધકારયુગો છે. જે યુગ વિષે આપણે પર્યાપ્ત પુરાવાઓ અને સાધનસામગ્રી ધરાવતા નથી તેને ઇતિહાસમાં અંધકારયુગ કહે છે. આ સંદર્ભમાં ડૉ. ડી. સી. સરકાર નોંધે છે કે, "જેના વિષે આપણી માહિતી અપર્યાપ્ત અને જાણકારી અવ્યવસ્થિત હોય છે એવા યુગને ઇતિહાસનો અંધકારયુગ કહેવામાં આવે છે. – – – આવા યુગના કોઈ પણ પાસા કે ભાગને અન્વેષણ દ્વારા ઇતિહાસકાર સફળતાપૂર્વક પ્રકાશમાં લાવે છે તો તે ઇતિહાસની પુનર્રચનાના કાર્યમાં સેવા બજાવે છે."[1] અને એ દ્વારા ઇતિહાસની કેટલીક ખૂટતી કડીઓ જોડવા મળી રહે છે. ડૉ. એ. ડી. પુસાળકર પણ અંધકારયુગ વિષે આ પ્રમાણે જણાવે છે: "ઇતિહાસના કોઈ પણ યુગ વિષે કોઈ પણ પ્રકારની ઐતિહાસિક સાધનસામગ્રીનો સંપૂર્ણ અભાવ હોય તો તેવા યુગને 'ઇતિહાસમાં' અંધકારયુગ કહેવામાં આવે છે.[2] આમ જેમની ઐતિહાસિક પુનર્રચના માટે આપણી પાસે પૂરતી સાધનસામગ્રી નથી એવા અર્થમાં ભારતીય ઇતિહાસમાં કેટલાક અંધકારયુગો છે. જ્યારે સ્વ. ડૉ. કે. પી. જયસ્વાલે 'ભારતનો ઇતિહાસ— ઇ. સ. ૧૫૦--૩૫૦' નામનો ગ્રંથ ૧૯૩૩માં બહાર પાડ્યો, ત્યારે ભારતીય ઇતિહાસમાં કેટલાક યુગો વિષે અલ્પ માહિતી મળતી હતી, તેથી તેમણે યથાર્થપણે એ યુગોની 'અંધકારયુગો' (હકીકતમાં તો કહેવાતા અંધકારયુગો)માં ગણના કરી છે.[3]

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* Previously Dr. R. K. Dharaiya has written two articles namely 'Nanda Period' and 'Sātvāhan Period' under the above heading in Vidyā, Vols. IX. No. 1 (Jan.' 66) pp. 91–99 and XI No. 2 (August, '67) pp. 107–117.

1. & 2. From their private letters addressed to me dated 27th Feb. 1970 and 24th March 1970 respectively.

3. The first paragraph in Dr. K. P. Jayaswal's 'History of India' [C. 150 A. D. to 350 A. D.] indicates what is meant by the Dark Period or Blank Period in history.

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ડૉ. સ્મિથના મંતવ્યને ડૉ. જયસ્વાલનો પડકાર

ડૉ. વી. એ. સ્મિથે તેમના 'અર્લી હિસ્ટરી ઑફ ઇન્ડિયા' નામના ગ્રંથમાં નોંધ્યું છે કે, "ભારતવર્ષના ઇતિહાસમાં કુશાણ તથા આંધ્રવંશનો નાશ [ઈ. સ. ૨૦૦ અથવા ૨૩૦ની આસપાસ] અને લગભગ એક સદી પછી સામ્રાજ્યવાદી ગુપ્તવંશનો ઉદય એ બે વચ્ચેનો યુગ ભારતીય ઇતિહાસના સમગ્ર ગાળામાં સૌથી અંધકારમય યુગોમાંનો એક છે."[4] તેમના કહેવાનું તાત્પર્ય એ છે કે આ યુગ વિષે કોઈ હકીકત જ્ઞાત નથી.

આજ સુધી [ઈ. સ. ૧૯૩૩ સુધી] ઇતિહાસકારોએ આ નિરાશાજનક બાબતને ચૂપચાપ સ્વીકારી લીધી હતી. પરંતુ જેટલી સાધનસામગ્રી ઉપલબ્ધ હતી તેટલાનું અધ્યયન કરીને ડૉ. કે. પી. જયસ્વાલે પ્રતિપાદન કર્યું છે કે ડૉ. સ્મિથનું ઉપર્યુક્ત મંતવ્ય હવે સ્વીકારી શકાય તેમ નથી તેમ જ ભવિષ્યમાં તેને ફરીથી દોહરાવવું પણ જોઈએ નહીં.[5] સદ્ભાગ્યે આ યુગ વિષે સાહિત્યિક, આભિલેખિક અને સિક્કાવિષયક સાધનસામગ્રી પર્યાપ્ત છે અને ખાસ કરીને તો આભિલેખિક તેમ જ સિક્કાવિષયક સાધનસામગ્રીમાં તો ઉત્તરોત્તર ઝડપથી ઉમેરો થતો રહે છે.[6] ડૉ. સ્મિથના ઉપરોક્ત ગ્રંથમાં વાકાટકોના ઇતિહાસ વિષે કોઈ પણ પ્રકારનો ઉલ્લેખ આવતો નથી. વાકાટકયુગનો ઇતિહાસ મુખ્યત્વે આધારભૂત તામ્રલેખો અને શિલાલેખોમાંથી[7] મળી રહે છે તેમ જ પુરાણોમાં[8] તેનો સાધારણ ઉલ્લેખ આવે છે, જેને ડૉ. કે. પી. જયસ્વાલ માને છે તેમ વાકાટકોના સિક્કાઓ[9] દ્વારા સમર્થન મળે છે. તેમ છતાંય ડૉ. સ્મિથે પ્રાચીન ભારતના ઇતિહાસનું વિહંગાવલોકન કરતી વખતે આ યુગની સદંતર ઉપેક્ષા કરી છે. પરિણામે આ યુગની ગણના ભારતીય ઇતિહાસના કેટલાક કહેવાતા અંધકારયુગોમાં થઈ છે.[10] હકીકતમાં ભારતીય ઇતિહાસમાં કમનસીબે આ અને આવા અન્ય કેટલાક કહેવાતા અંધકારયુગોએ "ઇતિહાસમાં ભજવેલા ભાગ વિષે મોટે ભાગે દુર્લક્ષ સેવાયું છે, અથવા તેમનું જોઈતું મૂલ્યાંકન થયેલું નથી...પરંતુ જે 'સાધનસામગ્રી' પ્રાપ્ય

4. Early History of India, 3rd Ed. (1914), p. 276. After Smith's death the 4th ed. of the said one is published in 1924 with few changes by S. M. Edwards. The same view is also recorded in his "Catalogue of the Coins in the Indian Museum" [1906], p. 95.
5. JBORS., Vol. XIX, p. 3.
6. JNSI., Vol. V (Presidential Address, 1942), p. 10.
7. Uptill now total 29 inscriptions of the Vākāṭakas are discovered and published in various Journals. See Appendix.
8. DKA., p. 48. See also R. Sathianthaier's remark "The history of the Vākāṭaka is based chiefly on inscriptions with some aid from the Purāṇas" [History of India, Vol. 1, 1961], p. 256.
9. Infra, fn 30. But we have thus so far discovered no coins of any Vākāṭaka ruler. Vide Sir Richard Burn in JIH., Vol. XV [1937], p. 260., Dr. A. S. Altekar in JNSI., Vol. V [1943], pp. 130–134 and Dr. V. V. Mirashi in ABNUHS., No. 1 [Oct. 1946], p. 9. D. C. Sirkar in AIU, p. 219 fn. 1
10. Dr. R. K. Dharaiya excludes the Vākāṭaka Period from the list of the so-called Dark Periods of the Indian history. Vidyā, IX. No. 1 [Jan. 66], p. 91;

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છે તેટલાનો પણ યોગ્ય રીતનો ઉપયોગ કરવાથી જે તે યુગો પર સારો એવો પ્રકાશ પડે છે તે નિ:શંક છે."[11] આ વિવરણના સંદર્ભમાં વાકાટકયુગનું અધ્યયન થવું ઘટે.

વાકાટકયુગનું મહત્ત્વ : દખ્ખણના ઇતિહાસમાં પાંચમી સદી—વાકાટક સદી

ડૉ. વી. વી. મિરાશીના મત મુજબ, "પ્રાચીન સમયમાં વાકાટક રાજવંશ દક્ષિણ ભારતના રાજકીય ઇતિહાસમાં થઈ ગયેલા સૌથી યશસ્વી રાજવંશોમાંનો એક હતો."[12] ઈ. સ. ત્રીજી સદીથી છઠ્ઠી સદીના શાસનકાળમાં વાકાટક રાજાઓએ નર્મદાથી તુંગભદ્રા અને અરબી સમુદ્રથી બંગાળના ઉપસાગર સુધી પોતાની આણ ફેલાવી હતી. આ વંશના રાજાઓએ પ્રાકૃત તેમ જ સંસ્કૃત સાહિત્યને ખૂબ ઉત્તેજન આપ્યું હતું એટલું જ નહીં, પરંતુ તેઓ પણ કવિઓ હતા.[13] સાહિત્ય-ક્ષેત્રની જેમ સ્થાપત્ય, શિલ્પ અને ચિત્રકલાના ક્ષેત્રે પણ વાકાટકોની સિદ્ધિઓ નોંધપાત્ર હતી. આ વંશ દ્વારા ગુપ્ત સામ્રાજ્યની ઉચ્ચ સંસ્કૃતિ અને ખાસ કરીને તો સંસ્કૃત સાહિત્ય દક્ષિણ ભારતના સમગ્ર ભાગમાં પ્રચાર અને પ્રસાર પામ્યું.[14] સંક્ષેપમાં વાકાટકોનો યુગ માત્ર તેમની રાજકીય સિદ્ધિઓને લીધે જ નહીં, પરંતુ સાહિત્ય, કલા અને ધર્મના ક્ષેત્રે તેમણે પ્રાપ્ત કરેલી અસાધારણ સિદ્ધિઓને લીધે પણ દખ્ખણના ઇતિહાસમાં યાદગાર બની રહેલો છે.

પ્રાચીન સમયમાં દખ્ખણના ઇતિહાસમાં વાકાટક રાજવંશનું મહત્ત્વ દર્શાવતાં સુપ્રસિદ્ધ ફ્રેન્ચ ઇતિહાસકાર ડૉ. જી. જે. દુબ્રેલ નોંધે છે કે "ઈ. સ. ત્રીજી સદીથી છઠ્ઠી સદી સુધી દખ્ખણમાં રાજ્ય કરી ગયેલા તમામ રાજવંશોમાં સૌથી યશસ્વી, આદરણીય સ્થાનને પાત્ર, સૌથી અદ્વિતીય અને સમગ્ર ભારતીય સંસ્કૃતિ પર ઊંડી અસર પહોંચાડી હોય તો તે નિ:શંકપણે વાકાટકોનો તેજસ્વી રાજવંશ છે."[15] પ્રાચીન સમયમાં દક્ષિણ અને ઉત્તર ભારતના ઇતિહાસમાં ચોથી--પાંચમી સદી દરમિયાન સાહિત્ય, ધર્મ, સ્થાપત્ય અને કલાના ક્ષેત્રે સર્વોત્કૃષ્ટ પ્રગતિ સધાઈ હતી, તેથી આ બે સદી દરમિયાનનો યુગ પ્રાચીન ભારતના ઇતિહાસમાં 'વાકાટક--ગુપ્ત યુગ'

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11. Loc. cit.
12. (a) ABNUHS., No. 1 [Oct. 1946], p. 8.
 (b) ABORI., Vol. XXXII., p. 1.
13. (a) IHQ., Vol. XXI, pp. 193–201.
 (b) Studies., Vol. 1 [1960], pp. 96–106.
14. (a) AHD., p. 75.
 (b) CSHI., p. 100.
 (c) Prāchīn Itihās [in Hindi--1948], p. 290, by G. P. Mehta.
 (d) India (1954), p. 69., by H. G. Rawlinson.
 (e) POC., 5th Session, p. 524.
 (f) SCHI., p. 178. See also Dr. Buddha Prakasha in VIJ., Vol. VII., p. 145.
 (g) For the contribution of the Vākātakas to Hindu Culture see Jayaswal in JBORS., Vol. XIX pp. 94–99 & 104–106.
15. AHD., p. 71.

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તરીકે જાણીતો છે. આ વંશે ઈ. સ. ૪૦૦થી ઈ.સ. ૫૦૦ વર્ષની સદી દરમિયાન તો દખ્ખણના ઇતિહાસમાં સર્વોચ્ચ સ્થાન ભોગવ્યું,[16] માટે તો પાંચમી સદીને દખ્ખણના ઇતિહાસમાં 'વાકાટક સદી' તરીકે ઓળખવામાં આવે છે, એવા પ્રા. દુબ્રૈલના વિધાનમાં અતિશયોક્તિને લેશ માત્ર પણ અવકાશ નથી.[17] વાકાટક યુગના ઇતિહાસના ઉદ્ધારક ડૉ. કે. પી. જયસ્વાલે તો ત્યાં સુધી કહ્યું છે કે "જો વાકાટકવંશ ન હોત તો ગુપ્ત સામ્રાજ્ય પણ ન હોત."[18] મહાન ગુપ્ત સામ્રાજ્યના ઇતિહાસની કટોકટીના તમામ તબક્કાઓમાં વાકાટકોએ ઓછેવત્તે અંશે નિર્ણયાત્મક ભાગ ભજવ્યો છે.[19]

વાકાટક યુગને લગતી સાધનસામગ્રી

૧. ઈ.સ. ૧૮૩૬નું વર્ષ વાકાટક ઇતિહાસમાં મહત્ત્વનું વર્ષ

પ્રાચીન સમયમાં દખ્ખણના ઇતિહાસમાં આટલું બધું મહત્ત્વનું સ્થાન ધરાવતા આ મહાન અને તેજસ્વી વંશનું નામ પણ ઈ. સ. ૧૮૩૬ સુધી કોઈ જાણતું ન હતું. તે ઇતિહાસમાં કમનસીબે એક 'ઉપેક્ષિત વંશ' અથવા તો 'અંધકારયુગ' તરીકે ઓળખાતો હતો. ઈ. સ. ૧૮૩૬માં મધ્ય પ્રદેશમાંથી પ્રાપ્ત થયેલ વાકાટક રાજવી પ્રવરસેન બીજાનો 'સિવની તામ્રલેખ' ડૉ. જેમ્સ પ્રિન્સેપે 'જર્નલ ઑફ ધી એશિયાટિક સોસાયટી ઑફ બેંગાલ'માં તે જ વર્ષના નવેંબરમાં પ્રસિદ્ધ કર્યો,[20] ત્યારે આ વંશ સર્વપ્રથમ અંધકારમાંથી પ્રકાશમાં આવ્યો.

પુરાણોમાં અને પ્રશિષ્ટ સંસ્કૃત સાહિત્યમાં વાકાટકોના નામનો ઉલ્લેખ પણ આવે છે. અલબત્ત, આ વંશના સંસ્થાપક 'વિંધ્યશક્તિ'ના નામનો ઉલ્લેખ પુરાણોમાં આવે છે, પરંતુ પુરાણોમાં તેનો 'વાકાટકોના રાજા' તરીકે નહીં પરંતુ 'કોલિકિલ જાતિના શાસક' તરીકે ઉલ્લેખ આવે છે.[21] વિષ્ણુપુરાણના વિવરણ મુજબ કોલિકિલ (અથવા કિલકિલા) રાજાઓની ગણના યવનો (ગ્રીકો)માં કરવામાં આવે છે.[22] હકીકતમાં તો અશુદ્ધ વાચનને લીધે ભૂલથી વિંધ્યશક્તિને યવન કે ગ્રીક જાતિનો માની લેવામાં આવ્યો હતો. ડૉ. ભાઉ દાજીએ પણ આ જ ભૂલ દોહરાવી છે,[23] જ્યારે ડૉ. જ્યોર્જ બ્યુલર[24] ડૉ. કે. પી. જયસ્વાલ[25] અને ડૉ. વી. વી. મિરાશી[26]

16. See also K. M. Munshi in BV., Vol. 2, p. 9.
17. See also Dr. K. P. Jayaswal in JBORS., Vol. XIX, p. 64.
18. Loc. cit.
19. (*a*) Dr. S. K. Aiyangar in QJMS., Vol. XV, p. 164.
(*b*) A. V. Venkataram Ayyar in QJMS., Vol. XVI, pp. 308–309.
20. JASB., Vol. V, pp. 726–731. For the Siwani Plates, see also (*i*) Fleet in CII., Vol. III [1963], pp. 243–249, (*ii*) Hiralal's List No. 78, p. 57, (*iii*) Dr. Mirashi in (*a*) CII., Vol. V [1963], pp. 28–32 and (*b*) NUJ., No. 1, pp. 1–3.
21. ततः कोलिकिलेभ्यश्च विन्ध्यशक्ति भविष्यति । DKA., p. 48.
22. Loc. Cit.
23. JBBRAS., Vol. VII, p. 66.
24. IA. Vol. XII, p. 242.
25. JBORS., Vol. XIX, pp. 68–69.
26. ABORI., Vol. XXXII, p. 2.

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નોંધે છે કે કોલિકિલ રાજાઓ યવન હતા એ અશુદ્ધ વાચન છે. વાકાટકો વિષે થોડી માહિતી વાકાટક રાજા પ્રવરસેન બીજાના 'સેતુબંધ'[27] નામના પ્રાકૃત મહાકાવ્યમાંથી તેમ જ મહાકવિ કાલિદાસકૃત 'મેઘદૂત'માં રામગિરિ પર્વતના ઉલ્લેખ દ્વારા મળી રહે છે. આ રામગિરિને ડૉ. મિરાશી[28] નાગપુર પાસેના વર્તમાન રામટેક માને છે.

સ્વ. કે. પી. જાયસ્વાલના મત મુજબ વાકાટકોનો મુખ્ય ઇતિહાસ પ્રમાણભૂત તામ્રપત્રો અને શિલાલેખોમાંથી પ્રાપ્ત થાય છે, તેમ જ પુરાણોમાં પણ તેમનો થોડોઘણો ઉલ્લેખ આવે છે, જેને વાકાટકોના સિક્કાઓ દ્વારા સમર્થન મળી રહે છે.[29] પરંતુ જેમને ડૉ. જાયસ્વાલે 'વાકાટકો-ના સિક્કાઓ'[30] તરીકે ઓળખાવ્યા છે તેમને ડૉ. એ. એસ. આલ્તેકરે 'કહેવાતા વાકાટક--સિક્કા-ઓ' તરીકે પુરવાર કરી બતાવ્યા છે એટલું જ નહીં, પરંતુ તેમણે નોંધ્યું છે કે આજ સુધી કોઈ પણ વાકાટક રાજાના સિક્કાઓ મળી આવ્યા નથી.[31] ડૉ. વી. વી. મિરાશી પણ આ મંતવ્યને અનુમોદન આપે છે અને દૃઢપણે માને છે કે વાકાટકોએ કદી પણ પોતાના નામના સિક્કાઓ પડાવ્યા નથી, તેઓ તો પોતાના સામ્રાજ્યમાં ચલણ તરીકે ગુપ્તોના સિક્કાઓનો ઉપયોગ કરતા હતા.[32]

વાકાટકવંશની વત્સગુલ્મ શાખાના રાજા હરિષેણના અમાત્ય વરાહદેવે અજંતાની સોળમી ગુફા[33] પર ઉત્કીર્ણ કરાવેલ લેખમાં પ્રારંભથી હરિષેણ સુધી વાકાટકોની વંશાવળી[34] આપવામાં

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27. Pravarasēna II's authorship of the Setubandha is rendered doubtful by the fact that while the theme of the Poem is Vaishṇava, the King was a devotee of S'iva [CA. pp. 183–84] Contra, Ramji Upadhyaya's article "The authorship of the Setubandha" in NIA., Vol. VII, Nos. 7–8, pp. 130–133 and Dr. A.D. Pusalkar in JASB[NS], Vols., 31—32, pp. 212--217.

28. (*a*) 'Location of Rāmagiri' in NUJ., No. 9, pp. 3–15.
(*b*) "Rāmagiri of Kālidāsa" in IHQ., Vol. 42, pp. 131–144.

Vide Dr. V. V. Mirashi's **मेघदूत में रामगिरि अर्थात् रामटेक.** Dr. Mirashi's view is recently supported whilelaying the Foundation Stone for a Kālidāsa Memorial at Rāmgiri, now called Rāmṭek near Nagpur by Shri V. P. Naik, Chief Minister of Maharsahrta, on December 17, 1968 ['Indological News and Notes' from VIJ., Vol. VI, p. 221.] See also V. K. Paranjpe's 'Fresh Light on Kālidāsa's Meghadūta' (1960).

29. JBORS., Vol. XIX, p.4.

30. Ibid., pp. 71–73 and Ibid., Vol. XXII., pp. 70--76.

31. See his article "Some Alleged Nāga And Vākāṭaka Coins" in JNSI, Vol. V. pp. 111–134.

32. (*a*) PIHC., 18th Session, p. 96., 23rd Session, pp. 188–190
(*b*) ABNUHS., No. 1, p. 9.
(*c*) CII., Vol V. [1963] p. XIV.
(*d*) Studies, Vol. IV [1966], pp. 225–226.

33. Vākāṭaka Inscription in Cave XVI At Ajaṇṭā [HAS. 14, pp. 2–9.]

34. For the Genealogy of the Vākāṭakas, refer to :
(*a*) Dr. Bhau Daji in JBBRAS., Vol. VII, pp. 65–66.
(*b*) Pandit Bhagvanlal Indraji in ICTWI [ASI, 1881] pp. 67–73.

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આવી છે. વેન્ગીના વિષ્ણુકુંડિન વંશના રાજાઓના 'ચિક્કુલ્લા અને રામતીર્થ તામ્રલેખો'માં પણ વાકાટકોનો ઉલ્લેખ આવે છે. હકીકતમાં વાકાટકોનો ઇતિહાસ આપણને મુખ્યત્વે તેમના તામ્રલેખો અને શિલાલેખોમાંથી મળી રહે છે. છેલ્લાં પચાસ વર્ષોમાં અન્વેષકો, સંશોધકો, ઇતિહાસવિદો વગેરેના સક્રિય પ્રયાસોના પરિણામે વાકાટક રાજાઓ, તેમના સામંતો અને તેમના મંત્રીઓએ બહાર પાડેલા કુલ ૨૯ અભિલેખો[34-A] આપણને આજ સુધીમાં પ્રાપ્ત થયા છે, જેમની સહાયથી આ વંશ વિષે સારા પ્રમાણમાં અધિકૃત માહિતી પ્રાપ્ત થઈ છે.

૨. પ્રભાવતીગુપ્તાનો 'પૂના-તામ્રલેખ' વાકાટકવંશનો કાળક્રમ નિર્ધારિત કરવાના ક્ષેત્રે સીમાચિહ્ન

ઈ. સ. ૧૯૧૨માં પૂનાના શ્રી. બળવંત ભાઉ નગરકર નામના કંસારાના ઘરમાંથી વાકાટક રાણી પ્રભાવતીગુપ્તાનો તામ્રલેખ મળી આવ્યો હતો.[35] પ્રા. કે. બી. પાઠકે સૌપ્રથમ 'ઇન્ડિયન ઍન્ટિકવેરી'માં[36] આ તામ્રલેખ અંગે સારાંશરૂપે હેવાલ રજૂ કર્યો. આ તામ્રલેખના રાજકીય મહત્ત્વને લીધે ઘણાય વિદ્વાનોનું તેના પ્રત્યે ધ્યાન દોરાયું અને ડૉ. વી. એ. સ્મિથે લંડનની રૉયલ એશિયાટિક સોસાયટીના જર્નલમાં પોતાના એક સંશોધન લેખમાં[37] આ તામ્રલેખનો ઉપયોગ કર્યો. આ ઉપરાંત પ્રા. કે. બી. પાઠક અને રાવબહાદુર કે. એન. દીક્ષિતે આ તામ્રલેખ અંગે 'ઍપિગ્રાફિયા ઇન્ડિકા'માં[38] અંગ્રેજી ભાષાંતર અને મૂળ છાપ સહિત સંશોધનપૂર્ણ લેખ પ્રસિદ્ધ કર્યો. આ તામ્રલેખના અધ્યયન પરથી સ્પષ્ટપણે ફલિત થાય છે કે વાકાટક મહારાજ રુદ્રસેન બીજાની

(*c*) Dr. Bühler in ASWI., Vol. IV, pp. 124–128, and IA. Vol. XII, p. 242.

(*d*) Dr. V. A. Smith in JRAS [London : 1914], pp. 322–328.

(*e*) Dr. S. K. Aiyangar in ABORI., Vol. V, pp. 32–35 and QJMS., Vol. XV, pp. 154–155.

(*f*) Dr. H. N. Randle in NIA., Vol. II, pp. 178–179.

(*g*) Mr. M. G. Pai in JIH., Vol. XIV., pp. 1–18.

(*h*) Sir Richard Burn, Ibid., Vol. XV, p. 260.

(*i*) A. Banerji-Sastri in JRASB [L], Vol. V, pp. 177–179.

(*j*) Dr. R. C. Majumdar, Ibid., Vol. XII, pp. 1–5.

(*k*) Dr. H. C. Raychaudhuri in PHAI., p. 565.

(*l*) Mr. Nisar Ahmed in IA, 3rd series, Vol. IV, pp. 149–164.

34-A. "અભિલેખોના બે પ્રકારો ઘણા પ્રચલિત છે, શિલાલેખો અને ધાતુલેખો............. શૈલલેખો [અથવા ખડકલેખો], સ્તંભલેખો અને ગુફાલેખો એ ત્રણેય શિલાલેખોના ઉપ-પ્રકારો છે." ડૉ. હરિપ્રસાદ શાસ્ત્રીનો સંશોધન લેખ 'ઇતિહાસ-સંશોધનના સાધન તરીકે અભિલેખોનો અભ્યાસ'. [શ્રી ફાર્બસ ગુજરાતી સભા ત્રૈમાસિક, પુસ્તક ૩૧, અંક ૩, પૃ. ૧૫૪.]

35. These Plates, though discovered with a copper-smith of Poona, really belong to the Hiṅgaṇghāt Tahsil of the Wardha district in Berar [EI., Vol. XXVI, p. 159] and the copper-smith with whom these plates were found originally hailed from Ahmadanagar [Loc. cit, fn. 1.]

36. IA. Vol. XLI. pp. 214–215.

37. Dr. V. A. Smith's article, 'The Vākāṭaka Dynasty of Berar in the 4th and 5th Centuries,' JRAS [London], 1914, pp. 317–338.

38. EI. Vol. XV, pp. 39–42.

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પટરાણી અને યુવરાજ દિવાકરસેનની માતા[39] પ્રભાવતીગુપ્તા[40] ગુપ્ત સમ્રાટ મહારાજાધિરાજ ચંદ્રગુપ્ત બીજાની પુત્રી હતી. આ હકીકત પરથી ગુપ્ત અને વાટાકટકવંશ વચ્ચેનો પરસ્પર સંબંધ જાણી શકાયો છે,[41] અને એ દ્વારા વાકાટકોનો કાળક્રમ સૌપ્રથમ સંગીન પાયા પર મુકાયો. આમ પ્રભાવતીગુપ્તાનો પૂના-તામ્રલેખ 'વાકાટક ઇતિહાસમાં કાળગણનાના ક્ષેત્રે સીમાચિહ્ન' બની રહે છે એટલું જ નહીં, પરંતુ એ. વી. વેંકટરામ અય્યરે નોંધ્યું છે તેમ તે 'The sheet-anchor of the Gupta-Vākāṭaka Synchronism' તરીકે ઓળખાય છે.[42] પ્રભાવતી ગુપ્તાના પૂના-તામ્રલેખની સહાયથી વાકાટકોનો કાળક્રમ નક્કી થતાં તેમના ઇતિહાસ વિષે આપણું જ્ઞાન ઉત્તરોત્તર વધતું જાય છે. આ તામ્રલેખને આધારે ડૉ. આર. સી. મજમુદાર,[43] શ્રી. એમ. જી. પાઈ,[44] ડૉ. ડી. સી. સરકાર,[45] ડૉ. વી. વી. મિરાશી[46] વગેરે વિદ્વાનોએ વાકાટકોનો કાળક્રમ નિર્ધારિત કર્યો છે. પરંતુ તાજેતરમાં મહારાષ્ટ્ર રાજ્યના અકોલા જિલ્લાના બાસીમની દક્ષિણે ૯½ કિલોમિટરના અંતરે આવેલ 'હિસે બોરાલા' (Hisse Borāḷā) નામના ગામમાંથી વાકાટકોની વત્સગુલ્મ શાખાના રાજા દેવસનનો શૈલલેખ[47] પ્રાપ્ત થતાં ઉપરોક્ત વિદ્વાનોએ નિર્ધારિત કરેલ વાકાટક-કાળક્રમ કામચલાઉ પુરવાર થયો છે, કારણ કે આજ સુધી પ્રાપ્ત થયેલ વાકાટકોના કુલ ૨૮ અભિલેખોમાંથી માત્ર ૧૪ અભિલેખો[48] રાજ્યારોહણ-વર્ષ (Regnal year)નો ઉલ્લેખ કરે છે, બાકીનામાંથી અમુકમાં તવારીખ નોંધવામાં આવેલી નથી,[49] કેટલાકના તવારીખવાળા ભાગ નષ્ટ

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39. वाकाटकानां महाराजश्रीरुद्रसेनस्याग्रमहिषी युवराज ।
[श्री] दिवाकरसेनजननी.....Ibid., p. 41, Lines 9 and 10 of the text. Besides she is also the mother of Dāmodarsēna-Pravarsēna See वाकाटकानाम्महाराजश्रीदामोदरसेनप्रवरसेनजननी, line 10 of the text of her Riddhapur plates published in JPASB., Vol. XX [NS.], p. 58.

40. Vide Dr. R. C. Majumdar in POC., 13th Session. pp. 423–425 and BV., Vol. XI, pp.1–3 and Dr. D.C. Sirkar in BV. Vol. XV, No. 3. pp. 8--9.

41. Vide Dr. S. K. Aiyangar in QJMS., Vol. XV, No. 2, pp. 153–164. Rev. H., Heras, S. J. in JBORS, Vol. XII, pp. 455--63.

42. QJMS., Vol. XVI, p. 308.

43. JRASB [L]., Vol. XII, pp. 1–5.

44. JIH., Vol. XIV., pp. 165–204.

45. AIU. p. 217 et Seq., CA., pp. 177 and ff.

46. (a) PIHC., 10th Session, pp. 84–90.
(b) IHQ., Vol. XXIV., pp. 148–55.

47. See (a) Dr. V. B. Kolte in (i) Taruṇ Bhārat [Marāṭhī weekly] dated 12–4–64. (ii) JVSM., 1964, pp. 134-56. (iii) MFV., pp. 372–387.
(b) Smt. Dr. Sobhana L. Gokhale in (i) S'ivas'akti [Marāṭhī daily] dated 26–4–64. (ii) Lokasattā [Marāṭhī daily] dated 22–3–64. (iii) EI. Vol. XXXVII, pp. 1–4.
(c) Dr. G. S. Gai & S. Sankaranerayanan, Ibid., pp. 5–8.
(d) Dr. D. C. Sirkar in JAIH., Vol I, Pts. 1–2, pp. 94–98.
(e) Dr. A. M. Sastri in JGJRI Vol. XXVI, pp. 617--27.

48. See Appendix., Nos. 2, 3, 4–5 [Set B] 6, 7, 8, 9, 10, 11, 12, 13, 14, 20, 24.

49. Ibid., Nos. 1, 21–22 [Set B] 23, 27.

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થઈ ગયા છે,[50] થોડાક અપૂર્ણ ઉત્કીર્ણ થયેલ હોવાથી[51] અથવા તો અધૂરા પ્રાપ્ત થયેલ હોવાથી[52] તેમાં તવારીખનો ઉલ્લેખ મળતો નથી, જ્યારે બોરાલા શૈલલેખ વાકાટક રાજા દેવસેનના શાસનકાળના ચોક્કસ વર્ષ (શક સંવત[53] ૩૮૦=ઈ.સ. ૪૫૮--૫૯]નો ઉલ્લેખ કરે છે.[54] આ રીતે બોરાલા શૈલલેખ અન્ય વાકાટક રાજવીઓના શાસનકાળનાં વર્ષો પણ નક્કી કરવામાં સીમાચિહ્ન બની રહે છે.[55] આમ આ શૈલલેખની પ્રાપ્તિના પરિણામે "વાકાટક--અભિભલેખો...માત્ર રાજ્યારોહણના વર્ષનો જ ઉલ્લેખ કરે છે," અને વાકાટક-અભિલેખોમાં "કોઈ પણ વાકાટક રાજવીની તવારીખ હજુ સુધી જાણી શકાઈ નથી." એવાં ત્રણ દાયકા પર અનુક્રમે ડૉ. એચ. એન. રૅન્ડલેએ[56] અને શ્રી. એમ. જી. પાઈએ[57] કરેલાં વિધાનો હવે અસત્ય પુરવાર થાય છે.

૩. ડૉ. સ્મિથ, પ્રોફે. દુબ્રૈલ અને ડૉ. એસ. કે. આયંગરનો ફાળો

ડૉ. વી. એ. સ્મિથે ૧૯૧૪માં બહાર પાડેલ તેમના "અર્લી હિસ્ટરી ઑફ ઇન્ડિયા" નામના ગ્રંથની ત્રીજી આવૃત્તિમાં વાકાટકો પ્રત્યે દુર્લક્ષ્ય સેવ્યું છે. પરંતુ લંડનની રૉયલ એશિયાટિક સોસાયટીના જર્નલના ૧૯૧૪ના અંકમાં તત્કાલીન સમયમાં ઉપલબ્ધ એવા વાકાટકોના નવ અભિલેખોનું[58] અધ્યયન કરીને બાવીસ પાનાંનો એક અધ્યયનપૂર્ણ સંશોધન લેખ લખ્યો,[59] અને તે રીતે તેમણે ભારતના પ્રાચીન ઇતિહાસમાં વાકાટકોનું સ્થાન નિશ્ચિત કર્યું. ત્યાર બાદ પ્રોફે. દુબ્રૈલ[60] અને ડૉ. એસ. કે. આયંગરે[61] પણ આ વંશ પર વધુ પ્રકાશ

50. Ibid., Nos. 16, 28, 29.
51. Ibid., Nos. 17, 18, 21-22 [Set A], 25.
52. Ibid., Nos. 4-5 [Set A], 16, 19.
53. On the question about the reckoning of the S'aka Era, refer to —
    (*a*) D. R. Bhandarkar in JBBRAS., Vol. XX, pp. 269-302.
    (*b*) V. S. Viswanatha, Ibid, Vol. XII (N.S.] pp. 100-102.
    (*c*) J. F. Fleet in (*i*) JRAS [London], 1910, pp. 818-824.
    (*ii*) CII, Vol. III, pp. 137-144.
    (*d*) G. Bose in JRASB [L], Vol. V, p. 96.
54. EI, XXXVII, Line 1 of the text, p. 3.
55. Vide fn. 47.
56. NIA., Vol. II, p. 178.
57. JIH., Vol. XIV, p. 165, See also V. V. Mirashi in ABORI., Vol. XXXII, p. 11 and D. C. Sircar in AIU., p. 219. now for Sircar's revised views, see JAIH Vol. I, pp. 94.
58. Smith's Serial No. 1 to 9 in JRAS (London : 1914), pp. 320-321, for this see Appendix Nos. 21-22 (set A and B) 6,7,10,27,28,29 and 2., respectively,
59. Supra fn. 37. Dr. V.A. Smith overlooked the 'Bālāghāt Plates of Prithivishe.a II' in this article and Dr. K. P. Jayaswal did not even take note of Smith's article mentioned in fn. 37, in his 'History of India' (150-350 A.D.). For Smith's Life and Work, refer to HIPC., pp. 266-274.
60. (*a*) AHD., pp. 71-76, (*b*) QJAHRS (1927), pp. 259, (*c*) IA., Vol. LV, p. 103.

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પાડયો છે. પ્રોફે. દુબ્રેલે વાકાટકવંશ વિષે સ્વતંત્રપણે તારવેલાં નિષ્કર્ષો હજુય અદ્વિતીય બની રહ્યાં છે. આ ક્ષેત્રે શ્રી. એ. વી. વેંકટરામ અય્યરની[62] સેવાઓ પણ નોંધપાત્ર છે.

૪. સ્વ. ડૉ. કાશીપ્રસાદ જયસ્વાલ (કે. પી. જયસ્વાલ)નું પ્રદાન

નાગ--વાકાટક સામ્રાજ્ય યુગીન ઇતિહાસના ઉદ્ધારક તરીકે જાણીતા સ્વ. ડૉ. કે. પી. જયસ્વાલે વાકાટકોના યશસ્વી ઇતિહાસ પ્રત્યે વિદ્વાનોનું અધિકમાં અધિક ધ્યાન દોર્યું છે. આ સંદર્ભમાં તેમની સેવાઓને બિરદાવતાં ડૉ. વી. વી. મિરાશી નોંધે છે કે, "સદ્‌ગત કે. પી. જયસ્વાલ વાકાટકોને 'અંધકારમાંથી' પ્રકાશમાં લાવ્યા અને ભારતના પ્રાચીન ઇતિહાસમાં તેમને યોગ્ય સ્થાને મૂકયા."[63] સૌરાષ્ટ્ર યુનિવર્સિટીના ભૂતપૂર્વ વાઇસ-ચાન્સેલર અને ગુજરાત ઇતિહાસ પરિષદના ભૂતપૂર્વ પ્રમુખ સ્વ. પ્રોફેસર ડોલરરાય માંકડે પણ ડૉ. જયસ્વાલે આ ક્ષેત્રે બજાવેલી સેવાનાં ભારોભાર વખાણ કર્યાં છે.[64] ઈ.સ. ૧૯૩૩માં પ્રસિદ્ધ થયેલ History of India [150-350 A.D.] નામના પોતાના ગ્રંથને ડૉ. જયસ્વાલે 'નાગ-વાકાટક સામ્રાજ્ય યુગ' [Nāga Vākāṭaka Imperial Period] એવું બીજું નામ આપ્યું છે.[65] આ ગ્રંથમાં તેમણે વાકાટક ઇતિહાસનાં વિવિધ પાસાંઓની છણાવટ કરી છે અને પ્રતિપાદન કર્યું છે કે "જો વાકાટકો ન હોત તો ગુપ્ત સામ્રાજ્ય ન હોત."[66] અલબત્ત, તેમણે વાકાટકવંશ વિષે રજૂ કરેલી કેટલીક હકીકતો અધ્યયનના અંતે આજે ખોટી પુરવાર થઈ ચૂકી છે.[67] તેમ છતાંય એટલું તો નિઃશંકપણે સ્વીકારવું પડશે કે તેમણે વાકાટક વંશની સિદ્ધિઓની જોરદાર શબ્દોમાં કરેલ તરફેણના પરિણામે આધુનિક લેખકોનું આ વંશ પ્રત્યે ધ્યાન દોરાયું છે.

૫. વિંધ્યશકિત બીજાનો 'બાસીમ તામ્રલેખ' વત્સગુલ્મ શાખા પર પ્રકાશ પાડે છે.

મહારાષ્ટ્રના અકોલા જિલ્લાના બાસીમ નામે ગામના પંડિત વાસુદેવશાસ્ત્રી ધનાગરે પાસેથી ઈ. સ. ૧૯૩૯માં વાકાટકવંશની વત્સગુલ્મ શાખાના વિંધ્યશકિત બીજાનો તામ્રલેખ

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61. (*a*) AISIHC., Vol. I, pp. 91–166.
(*b*) ABORI., Vol. V, pp. 31–54.
(*c*) QJMS., Vol. XV, pp. 153–164.
(*d*) IA., Vol. LV., pp. 223–227. For Dr. S.K. Aiyangar's Life and Work, see ACV., pp. IX-XIV and 498–500.

62. (*a*) JOR., 1927, pp. 87–91.
(*b*) QJMS., Vol. XVI, pp. 306–309.

63. ABORI., Vol. XXXII, p. 4.

64. Poc., 21st Session, p. 267.

65. Dr. K. P. Jayswal's 'History of India' is also translated into Hindi under the heading 'भारतवर्ष का अंधकारयुगीन इतिहास' by Rāmchandra Varma.

66. Supra fn. 18.

67. See (*a*) A. S. Altekar in JNSI., Vol. V, pp. 130–134.
(*b*) Dr. V. V. Mirashi in ABORI., Vol. XXXII, pp. 11.
(*c*) H. D. Sankalia in PIS., pp. 194, 208,

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(જે બાસીમ તામ્રલેખ[68] તરીકે ઓળખાય છે) મળી આવ્યો, તે પહેલાં લગભગ બધા જ ઈતિહાસકારો માનતા હતા કે વાકાટકવંશ અંત સુધી અખંડિત રહ્યો હતો.[69] પરંતુ શ્રી. ડી. બી. મહાજન અને ડૉ. વી. વી. મિરાશીએ આ તામ્રલેખનું 'એપિગ્રાફિયા ઈન્ડિકા'માં[70] સંપાદન કરતાં પ્રતિપાદન કર્યું કે પ્રવરસેન પહેલાના અવસાન પછી વાકાટકવંશ ચાર શાખાઓમાં વહેંચાઈ ગયો હતો.[71]

પુરાણોના વિવરણ મુજબ પ્રવીર (ઉર્ફે પ્રવરસેન પહેલો[72])ને ચાર પુત્રો હતા, જે ભવિષ્યમાં રાજ્ય કરશે.[73] પ્રવરસેન પહેલાનો જ્યેષ્ઠ પુત્ર ગૌતમી પુત્ર તેની હયાતી દરમિયાન અકાલ અવસાન પામતાં તેના પૌત્ર રુદ્રસેન પહેલાએ 'નંદિવર્ધન શાખા' સ્થાપી. પ્રવરસેન પહેલાના બીજા પુત્ર સર્વસેનનો ઉલ્લેખ બાસીમ તામ્રલેખમાં આવે છે. આ સર્વસેને વત્સગુલ્મ શાખા (બાસીમ શાખા) સ્થાપી. સર્વસેન પછી તેનો પુત્ર વિંધ્યશક્તિ બીજો ગાદીએ આવ્યો. પ્રવરસેન પહેલાના બાકીના બે પુત્રોનાં નામ હજુ જાણી શકાયાં નથી,[74] પરંતુ તેઓ અનુક્રમે ગોદાવરીની દક્ષિણે કુંતલ અને કોસલ (છત્તીસ ગઢ) પ્રદેશમાં રાજ્ય કરતા હશે એવો સંભવ છે. ઈ. સ. ૩૭૫ની આસપાસ રાષ્ટ્રકુટ રાજા માનાંકે કુંતલ પ્રદેશ પર પોતાનું રાજ્ય સ્થાપ્યું, પરિણામે ત્યાંથી વાકાટકશાખાનો અંત આવ્યો.[75]

આ પ્રમાણે બાસીમ તામ્રલેખ પ્રવરસેન પહેલો, પુત્ર સર્વસેન અને પૌત્ર વિંધ્યશક્તિ બીજો એવી વાકાટક વંશાવળી રજૂ કરે છે. આ હકીકત વાકાટકવંશની બીજી શાખાનો નિર્દેશ કરે છે, કારણ કે પ્રવરસેન બીજા અને પૃથ્વીષેણ બીજાના તામ્રલેખોના વિવરણ મુજબ પ્રવરસેન પહેલા પછી તેનો પૌત્ર અને ગૌતમીપુત્રનો પુત્ર રુદ્રસેન પહેલો ગાદીએ આવ્યો, એટલે પ્રવરસેન પહેલાનો પુત્ર સર્વસેન વાકાટકોની વત્સગુલ્મ શાખાનો સંસ્થાપક હતો, અને તેના પછી તેનો પુત્ર વિંધ્યશક્તિ ગાદીએ આવ્યો.

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68. Vide Appendix No. 24.
69. Dr. S. K. Aiyangar following Dr. Kielhorn [EI, Vol. IX, p. 269.] thought that there was a disputed succession after the death of Pravarasēna II and his son Narēndrasēna took the kingdom from an elder brother [ABORI, Vol. V, pp. 4–5, 35]. Contra Dr. K. P. Jayaswal, Mr. M. G. Pai & Dr. V. V. Mirashi in भाअंयुइ, pp. 183–85, JIH, Vol. XIV, pp. 5–6 & CII, Vol. V, pp. XXV, 78–80, respectively.
70. Infra Appendix No. 24-b.
71. See also Dr. R. C. Majumdar in JRASB [Letters], Vol. XII, p. 1.
72. This identification is well-established by (*i*) Dr. S. K. Aiyangar, OP. cit, p. 5. (*ii*) Dr. K. P. Jayaswal, OP. cit, pp. 27, 143, (*iii*) Mr. M. G. Pai, OP. cit, pp. 15, 168, (*iv*) Dr. D. C. Sirkar. in IHQ, Vols. XVI, pp. 183, 186, XVII, p. 111, (*v*) Dr. A. S. Altekar in VGA (60), p. 98 and EHD, p. 163, and (*vi*) Dr. V. V. Mirashi in ABNUHS, No. 1, p. 12.
73. After referring to Pravira [Pravarasēna I] the Purāṇas say तस्य पुत्रास्तु चत्वारो भविष्यन्ति नराधिपाः ॥ [DKA, p. 50]
74. Mr. M. G. Pai is the only author who mentions the names of all the four sons of Pravarasēna I in JIH, Vol. XIV, p. 18.
75. Vide Dr. V. V. Mirashi in ABORI, Vol. XXV, pp. 36ff and studies, Vol. I, pp. 178–88.

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૬. ડૉ. મજુમદાર, ડૉ. ડી. સી. સરકાર અને ડૉ. આલ્તેકરની સેવાઓ

ડૉ. આર. સી. મજુમદાર[76] અને ડૉ. ડી. સી. સરકારે[77] ઇતિહાસને લગતાં વિવિધ જર્નલોમાં વાકાટકવંશ વિશે નોંધપાત્ર સંશોધન લેખો લખીને આ ક્ષેત્રે કીમતી સેવા બજાવી છે. મુંબઈની ભારતીય વિદ્યાભવન દ્વારા પ્રકાશિત 'ધી એજ ઑફ ઇમ્પીરિયલ યુનિટી' [આવૃત્તિ ૧૯૬૦][78] અને 'ધી ક્લાસિકલ એજ' [આવૃત્તિ ૧૯૭૦][79]માં તેમ જ ભારતીય ઇતિહાસ કૉંગ્રેસ અને ભારતીય ઇતિહાસ પરિષદની યોજના હેઠળ પ્રસિદ્ધ થયેલ 'એ કોમ્પ્રીહેન્સિવ હિસ્ટરી ઑફ ઇન્ડિયા', ગ્રંથ ૨ માં[80] ડૉ. ડી. સી. સરકારે વાકાટકવંશ વિષે ઉલ્લેખનીય પ્રકરણો લખ્યાં છે. વળી તેમણે સંપાદિત કરેલ સિલેકટ ઇન્સ્ક્રિપ્શન્સ [આવૃત્તિ ૧૯૬૫][81]માં પણ વાકાટકોના છ અભિલેખો અંગે ટીકાત્મક વિવરણ આપેલું છે. ડૉ. આર. સી. મજુમદાર[82] અને સ્વ. ડૉ. એ. એસ. આલ્તેકર દ્વારા સંપાદિત 'ધી વાકાટક ગુપ્ત એજ' [પ્રથમ આવૃત્તિ, ૧૯૪૬] નામના ગ્રંથમાં[83] ડૉ. આલ્તેકરે વાકાટકવંશ વિષે થયેલાં ઐતિહાસિક અન્વેષણો અને સંશોધનોના આધારે ૩૩ પાનાંનું એક સ્વતંત્ર પ્રકરણ લખ્યું છે, તથા ડૉ. જી. યાજદાની દ્વારા સંપાદિત 'ધી અર્લી હિસ્ટરી ઑફ ધી ડૅક્કન [આવૃત્તિ ૧૯૬૦], ભાગ ૧--૪'માં[84] ડૉ. આલ્તેકરે વાકાટકો વિષે અગાઉ કરતાંય અધિક સારી એવી માહિતી આપી છે. અગાઉ નોંધ્યું છે તેમ જેમને ડૉ. જયસ્વાલે વાકાટકોના સિક્કાઓ તરીકે ઓળખાવ્યા છે તેમને ડૉ. આલ્તેકરે કહેવાતા વાકાટક-સિક્કાઓ તરીકે પુરવાર કરી બતાવ્યા છે. ડૉ. આલ્તેકરે ઇતિહાસનાં વિવિધ જર્નલોમાં[85] પણ વાકાટકવંશ વિષે સંશોધન લેખો લખીને વાકાટક ઇતિહાસનાં કેટલાંક મહત્ત્વનાં પાસાં છતાંકર્યાં છે.

૭. ડૉ. વી. વી. મિરાશીનો અમૂલ્ય ફાળો

નાગપુરની મૉરિસ કૉલેજના ભૂતપૂર્વ પ્રાચાર્ય તેમ જ નાગપુર યુનિવર્સિટીના પ્રાચીન ભારતીય ઇતિહાસ અને સંસ્કૃતિના ભૂતપૂર્વ અધ્યક્ષ અને નાગપુરના 'વિદર્ભ સંશોધન મંડળ'ના વર્તમાન પ્રમુખ શ્રી. મહામહોપાધ્યાય ડૉ. વી. વી. મિરાશીએ 'મહાદેવ હરિ વાઠોડકર વ્યાખ્યાન-માળા' હેઠળ નાગપુર યુનિવર્સિટીના સભાખંડમાં તા. ૫, ૬, ૭ અને ૯મી માર્ચ, ૧૯૫૮ના રોજ વાકાટકોના રાજકીય અને સાંસ્કૃતિક પાસાંઓ પર અધ્યયનપૂર્ણ વ્યાખ્યાનો આપીને વાકાટકોના

76. (a) JRASB (L)., Vol. XII, pp. 1–5., and pp. 75–76.
(b) Poc., 13th Session, pp. 423–25 and BV., Vol. XI, pp. 1–3.
77. (a) JRASB [L]., Vols. XII, pp. 71–73, XIII, pp. 75–78.
(b) See Appendix, No. 24–c, d and e.
(c) Supra fn, 47–d.
78. AIU., Ch. XIV, pp. 217–221.
79. CA., Ch. XI, pp. 177–188.
80. CHI., Ch., pp. 328–331.
81. SI. pp. 430--56.
82. The doyen of historians in India [BV., Vol. XI, p. 122].
83. VGA., Ch. V, pp. 93–125.
84. EHD., Pt. III, pp. 149–201.
85. namely (a) JNSI., Vol. V, pp. 111–134,
(b) IC., Vol. IX, pp. 99–106. For Dr. Altekar's Life and Work see AMV, pp. 460–464 and PIHC, 22nd session, pp. 34–42

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ઇતિહાસને અંધકારમાંથી પ્રકાશમાં લાવવામાં અદ્વિતીય અને અમૂલ્ય ફાળો આપ્યો છે. તેમણે એપિગ્રાફિયા ઇન્ડિકા, જર્નલ ઑફ ઇન્ડિયન હિસ્ટરી, એનલ્સ ઑફ ભાંડારકર ઓરિએન્ટલ રિસર્ચ ઇન્સ્ટિટ્યૂટ, ઇન્ડિયન હિસ્ટોરિકલ કવાર્ટર્લી, પ્રોસિડિંગ્સ ઑફ ઇન્ડિયન હિસ્ટરી કૉંગ્રેસ, પ્રોસિડિંગ્સ ઑફ ઑલ-ઇન્ડિયા ઓરિયેન્ટલ કૉન્ફરન્સ, નાગપુર યુનિવર્સિટી જર્નલ, એન્યુઅલ બુલેટિન ઑફ નાગપુર યુનિવર્સિટી હિસ્ટોરિકલ સોસાયટી, હૈદરાબાદ આર્કિયોલૉજિકલ સિરીઝ, જર્નલ ઑફ ધી ન્યૂમિસ્મૅટિક સોસાયટી ઑફ ઇન્ડિયા, કોમેમોરેટિવ એન્ડ ફેલિસિટેશન વૉલ્યુમ્સ વગેરેમાં વાકાટકો વિષે સંશોધન લેખો અને આભિલેખિક નોંધો લખીને આ યુગને પ્રકાશમાં લાવવામાં અમૂલ્ય સેવા બજાવી છે. તેમણે તેમ જ અન્ય વિદ્વાનોએ ઇન્ડિયન ઍન્ટિકવેરી, પ્રોગ્રેસ રિપોર્ટ ઑફ ધી આર્કિયોલૉજિકલ સર્વે ઑફ વેસ્ટર્ન ઇન્ડિયા, કૉર્પસ ઇન્સ્ક્રિપ્શનમ્ ઇન્ડિકેરમ (ભાગ ૩), જર્નલ ઑફ બૉમ્બે બ્રાન્ચ ઑફ રૉયલ એશિયાટિક સોસાયટી અને ઉપર્યુક્ત ઉલ્લેખિત જર્નલોમાં અને ખાસ કરીને 'ઍપિગ્રાફિયા ઇન્ડિકા'માં વાકાટકોના તામ્રપત્રો અને શિલાલેખોને અંગ્રેજી અનુવાદ અને ટીકાત્મક વિવરણ સહિત મૂળ છાપવાળા પ્રસિદ્ધ કર્યા છે. ત્યાર બાદ આ બધાં તામ્રપત્રો અને શિલાલેખોને 'વાકાટકોના અભિલેખો'[86] એવા નામે તેમણે ગ્રંથકારે સંપાદિત કર્યા છે. આ ગ્રંથ ભારત સરકારના આર્કિયોલૉજિકલ વિભાગે પ્રસિદ્ધ કર્યો છે. વાકાટકો અને અન્ય વંશો પરના તેમના સંશોધન લેખો અને આભિલેખિક નોંધો તેમના 'સ્ટડીઝ ઇન ઇન્ડોલૉજી', ભાગ ૧--૪માં[87] સમાવિષ્ટ કરવામાં આવેલા છે. વાકાટક ઇતિહાસના ક્ષેત્રે ડૉ. મિરાશીની સેવાઓને બિરદાવતાં ડૉ. એસ. બી. દેવ નોંધે છે કે, "વાકાટકવંશનાં વિવિધ પાસાંઓને સ્પર્શતી બાબતોને 'અંધકારમાંથી' પ્રકાશમાં લાવવાનો યશ ડૉ. મિરાશીને જાય છે. તેમણે વાકાટકોનો કાળક્રમ, તેમનું મૂળવતન, ગુપ્તો સાથેના તેમના સંબંધો અને તેમની રાજધાનીઓને લગતાં સૌથી અધિક સ્વીકૃત મંતવ્યો ઓછાવત્તા અંશે સફળતાપૂર્વક રજૂ કર્યાં છે."[88] ડૉ. વાય. કે. દેશપાંડે પણ નોંધે છે કે ખાસ કરીને વિદર્ભના વાકાટકો અને ત્રિપુરીના કલચુરીના ઇતિહાસને પુનઃ રચવાનો યશ ડૉ. મિરાશીને જાય છે.[89] આ બધાંના પરિણામે ડૉ. વી. વી. મિરાશી 'વાકાટક યુગના ઉદ્ધારક' તરીકે ઇતિહાસમાં અદ્વિતીય સ્થાનના અધિકારી બન્યા છે.

આ પ્રમાણે ઉપર્યુક્ત ભારતીય અને વિદેશી ઇતિહાસકારોએ તેમ જ અન્ય ઇતિહાસવિદો, અન્વેષકો અને સંશોધકોએ[90] ભારતીય ઇતિહાસના કહેવાતા અંધકારયુગ એવા વાકાટકયુગને લગતા અભિલેખોનું વિશ્લેષણાત્મક અધ્યયન કરીને આ યુગના ઇતિહાસનાં વિવિધ પાસાંઓને સમૃદ્ધ બનાવ્યાં છે. પરિણામે આ યુગ હવે "અંધકારયુગ" રહ્યો નથી.[91]

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86. Inscriptions of the Vākāṭakas [Corpus Inscriptionum Indicarum, Vol. V, 1963], The name ' Corpus Inscriptionum Indicarum ' (Collection of Indian Inscriptions) is suggested by James Prinsep in 1837, CII., Vol. 3, Preface.
87. Studies; Vols. I (1968), II (1961), III (1962) and IV (1966).
88. Review, p. 183.
89. Ibid., p. XXXVI.
90. See Summary, Section D, 2–Vi.
91. Of course, the Vākāṭaka dynasty was not "known to scholars of previous generation until inscriptions revealed ' its ' past ", Dr. K. K. Pillai in JMU., Vol. XXVIII, p. 164.

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ઋણસ્વીકાર

વાકાટક યુગ વિષેનો આ સંશોધન લેખ તૈયાર કરવામાં સહાયભૂત થવા બદલ હું ડૉ. એ. ડી. પુસાળકર,[92] ડૉ. વી. વી. મિરાશી,[93] ડૉ. ડી. સી. સરકાર,[94] ડૉ. બુદ્ધપ્રકાશ,[95] ડૉ. એ. આર. જી. તિવારી,[96] અને ડૉ. એચ. ડી. સાંકળિયા[97] વગેરે પ્રાધ્યાપક સાહેબોનો ખૂબ આભાર માનું છું.

SUMMARY

The so-called Dark Periods of the Indian History

[3] The Vākāṭaka Period

1. Sources of the Period

(A) What is meant by Dark Period ?

Dr. D. C. Sirkar's definition—Dark Period means a Period of history about which our information is insufficient and knowledge hazy. This view is supported by Dr. A. D. Pusalkar and Dr. R. K. Dharaiya.

(B) Dr. Smith's view challenged by Dr. Jayaswal ;

Smith's view about D. P. in his Early History of India is challenged by Jayaswal in his History of India. Smith had totally neglected this period in his EHI.

(C) Importance of the Period :

Its importance in the history is stressed by Dr. Mirashi, Prof. Dubreuil, Dr. Jayaswal and a number of other historians. The 5th century is the century of the Vākāṭaka in the history of the Deccan.

(D) Sources of the Period :

(1) Inscriptions, Coins, Seals and Literature :

Total 29 inscriptions accessible to us to re-construct the history of the Vākṭāaka dynasty. Dr. Jayaswal deciphered

92. Director, Bhandrakar Oriental Research Institute, Poona.
93. Chairman, Vidarbha Saṁśodhan Maṇdal, Nagpur.
94. Professor and Head of the Department of Ancient Indian History and Culture, and Director of the Centre of Advanced Study in AIHC, Calcutta University, Calcutta.
95. Director, Institute of Indic Studies, Kurukshetra University, Kurukhsetra.
96. Reader and Head of the Department of History, Sardar Patel University, Vallabh Vidyanagar.
97. Director, Deccan College and Post-graduate Research Institute, Poona.

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Vākāṭaka coins, but Dr. Mirashi, following the late Dr. Altekar, firmly maintains that the Vākāṭaks never issued any coins. This period not known to literature except that some inferences can be drawn from Purāṇas, Pravarsēna II's Setubandha Kāvya and Kālidāsa's Meghadūta.

(2) Contributions of the historians, epigraphists, orientalists, etc.,

(*i*) Dr. James Prinsep :

The name of this dynasty unknown till the publication of the first copper grant of the Vākāṭaka (Seonī Plates of Pravarasena II) discovered from Seonī in C.P. by Dr. Prinsep in 1836.

(*ii*) Dr. Smith, Prof. Dubreuil, Dr. Aiyangar and Shri Ayyar :

They threw more light on the history of this royal family.

(*iii*) Dr. K. P. Jayaswal :

He particularly sought to light up the so-called dark period by bringing our notice the inportance of the Vākāṭakas and assigned them their rightful place in the Ancient History of India. His services in this regards are appreciated by Dr. Mirashi and Prof. D. R. Mankad.

(*iv*) Dr. Majumdar, Dr. Sircar and Dr. Altekar :

Dr. Majumdar—the doyen of historians in India, Dr. D. C. Sircar and Dr. A. S. Altekar have contributed many research papers and separate chapters on the history of this dynasty in various journals and books.

(*v*) Dr. V. V. Mirashi :

He has written many research articles and epigraphic notes on the Vākāṭaka history in various historical, indological and epigraphical journals. He has delievered four lectures on the various aspects of the Vākāṭaka dynasty under the auspicious of "Mahadev Hari Vathodakar Lecture Series" held by Nagpur University in 1956. He has also edited the inscriptions of this dynasty known as Inscriptions of Vākāṭakas [CII., Vol. V].

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(*vi*) Other historians, epigraphists and orientalists, etc. :

Dr. James Prinsep [mentioned above], Sir General Cunningham, Dr. Burgess, Dr. Bühler, Pandit Indraji, Bhau Daji, Dr. Kielhorn, Dr. J. F. Fleet, Rai Bahadur Hiralal, Dr. V. S. Sukhathankar, Prof. K. B. Pathak, Mr. K. N. Dikshit, T. A. Wellsted, Mr. G. Ramadas, Mr. Y. B. Kale, Dr. G. Yazdani, Dr. B. Ch. Chhabra, Dr. H. N. Randle, Dr. H. D. Sankalia, Dr. Y. K. Despande, Mr. D. B. Mahajan, Dr. V. B. Kolte, Dr. A. D. Pusalkar, Dr. A. M. Sastri, Mr. J. M. Nanavati, Smt. Dr. Sobhana L. Gokhale, etc., have contributed to light up this so-called period of the Indian History by writing research papers as well as epigraphical and indological notes in various Journals.

Appendix

A list of the Vākāṭaka Inscriptions

[A] Inscriptions of the Main Branch

1. Dēoṭek Stone Inscription of Rudrasēna I
   Ref :—(*a*) ASIR., Vol. 7, pp. 123–125., (*b*) CII., Vol. I, pp. 28–29, (*c*) POC., 8th Session, pp. 613–624., (*d*) Studies., Vol. I, pp. 109–117.
   (*e*) Hiralal's List, No. 12, p. 14. (*f*) વિદ્યાપીઠ, અંક ૨, ૧૯૭૧ [પ્રસિદ્ધ થશે].

2. Poonā Plates of Prabhāvatī Guptā—13th Ry, Line 22 of the text.
   Ref :—(*a*) IA., Vol. XLI, pp. 214–215., (*b*) EI., Vol. XV., pp. 39–42, (*c*) HLI., pp. 111–112. (*d*) SI, pp. 435–38 (*e*) S. Ram's List No. 47, pp. 116–18.

3. Jāmb Plates of Pravarasēna II–2nd Ry, Line 35 of the text.
   Ref :—EI., Vol. XXVI, pp. 155–161.

4–5. Bēlōrā Plates of Praverasēna II
   Ref :–EI., Vol. XXIV, pp. 260–267.
   (*a*) Set A.
   (*b*) Set B–13th Ry, Line 30 of the text., p. 267.

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6. Chammak Plates of Praversēna II-18th Ry, Line 60 of the text.
   Ref :—(*a*) ASWI., Vol. IV, pp. 116-124.,
   (*b*) CII., Vol. III, pp. 235-243,
   (*c*) IA., Vol. XII, pp. 239-247.
   (*d*) Hiralal's List, No. 174, p. 125.
   (*e*) SI, pp. 442-49.
   (*f*) S. Ram's List, No. 48, pp. 118-23.

7. Siwanī Plates of Pravarasēna II-18th Ry, Line 18 of the text.
   Ref :— Supra fn. 20.

8. Ṛiddhapur Plates of Prabhāvatī Guptā-19th Ry, Line 30 of the text.
   Ref :—(*a*) JPRASB., Vol. XX[NS], pp. 53-60. (*b*) SI, pp. 439-42
   (*c*) S. Ram's List, No. 46, pp. 113-16.

9. Indore Plates of Pravarasēna II-23rd Ry, Line 33 of the text.
   Ref :—(*a*) EI., Vol. XXIV, pp. 527 ff, (*b*) HLI., 118-120.

10. Dudiā Plates of Pravarsēna II-23rd Ry, Line 28 of the text.
    Ref :—EI., Vol. III, pp. 258-262 and Hiralal's List, No. 114, p. 114.

11. Tirōḍī Plates of Pravarasēna II-23rd Ry, Line 31 of the text.
    Ref :—EI., Vol. XXII, 167-176.

12. Waḍgaon Plates of Pravarasēna II-25th Ry, Line 41 of the text.
    Ref :—EI., Vol. XXVII, pp. 74-79 (*b*) JBBRAS [1946], Vol, 22, pp. 49-54.

13. Paṭṭan Plates of Pravarasēna II-27th Ry, Line 43 of the text.
    Ref :—EI., Vol. XXIII, pp. 81 and ff.

14. Pāṇḍhurṇā Plates of Pravarasēna II-29th Ry, Line 53 of the text.
    Ref :—CII., Vol. V, pp. 63-68 and Plate XIV.

15. Paṭnā Museum Plate of Pravarsēna II
    Ref :—(*a*) JBORS. Vol. XIV, pp. 465-475., (*b*) NUJ., No.2, pp. 48-50.

16. Rāmṭēk Plate of Pravarasēna II,
    Ref :—(*a*) NUJ., No. 3, pp. 20-21, (*b*) Inscriptions in C.P. and Berar (2nd Ed.) pp. 4-5 by Dr. Hiralal.

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17. An Unfinished Durg Plate
    Ref :—EI. Vol. XXII, pp. 207–212.

18. Bālāghāṭ Plates of Prithivishēṇa II,
    Ref :—EI., Vol. IX, pp. 267 and Hiralal's List No. 22 pp. 17–18.

19. A new Vākāṭaka Copper Plate Inscription
    Ref :—JoI, Vol. 10, p. 408.

[B] Inscriptions of the Feudatories of the Main Branch

20. Bamhanī Plates of Bharatbala–2nd Ry, Line 47 of the text, p. 143.
    Ref :—(*a*) EI., Vol. XXVII, pp. 132–144, (*b*) Indica., pp. 268–273.

21–22. Nachnē-Kī-Talāī. Stone Inscriptions of Vyāghradēva (set A and B)
    Ref :—(*a*) ASIR., Vol. XXI, pp. 97 ff, (*b*) CII., Vol. III, pp. 233–235.

23. Ganj Stone Inscription of Vyāghradēva
    Ref :—EI., Vol. XVII, pp. 12ff and p. 362., SI, p. 456.

[C] Inscriptions of the Vatsagulma Branch

24. Bāsim Plates of Vindhyaśakti II–37th Ry, Line 28 of the text.
    Ref :—(*a*) PIHC., 3rd session, pp. 449–60
    (*b*) EI, XXVI, pp. 137–144
    (*c*) IHQ., Vols. XVI, pp. 182–186., XVII, pp. 110–116
    (*d*) SI., Vol. I, pp. 430–35
    (*e*) IC., Vol. VIII, pp. 394–396
    (*f*) HLI., pp. 111–112.

25. An Unpublished India Office Plate of Dēvasēna
    Ref :—NIA., Vol. II, pp. 177–180 and 721–723.

26. Hisse Borālā Inscription of Dēvasēna– 380 Saka Era
    Ref :—Supra fn. 47.

[D] Inscriptions of the Ministers and Feudatories of the Vatsagulma Branch.

27. Ajaṇṭā Cave Inscription of Varāhadēva.
    Ref :—(*a*) Supra fn. 33 and 34–a,b,c. (*b*) NUJ, No. 6, pp. 41ff.
    [cf. EI, Vol. XXVI, pp. 146ff.]
    (*c*) IC., Vol. VII, pp. 372ff., (*d*) HLI., pp. 114–118.

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28. Ghaṭōtkach Cave Inscription of Varāhadēva.

Ref :—(*a*) ICTWI [1881]., pp. 88ff.
(*b*) ASWI., Vol. IV, pp. 138–140.
(*c*) HAS., No. 15.

29. Inscription in Ajaṇṭā Cave XVII.

Ref :—(*a*) JBBRAS., Vol. VII, pp. 59–61 ,
(*b*) ICTWI [1881], p 73ff
(*c*) ASWI , Vol. IV, pp. 128 ff.
(*d*) HAS , No 15, [1949].

N.B.—For the detailed discussion of the Inscriptions, the reader is requested to refer to Dr. V. V. Mirashi's CII., Vol. V. (1963).

A List of Abbreviations

ABORI Annals of the Bhandarkar Oriental Research Institute, Poona.

ABNUHS Annual Bulletin of the Nagpur University Historical Society, Nagpur.

ACV Dr. S. K. Aiyangar Commemoration Volume.

AHD Ancient History of the Deccan [1920], by G. Jouveau Dubreuil.

AISIHC Ancient India and South Indian History and Culture, Vol. 1, [1941] by S. Krishnaswami Aiyangar.

AIU The Age of Imperial Unity [1960], eidted by R. C. Majumdar and A. D. Pusalkar.

AMV A. S. Altekar Memorial Volume [JBRS., Vol. XLV, 1959]

ASWI Archaeological Survey of Western India

BV Bhāratiya Vidyā, Bombay.

CA The Classical Age [1962], edited by R. C. Majumdar and A. D. Pusalkar.

CHI A Comprehensive History of India, Vol. II [1957], ed. by K. A. Nilakanta Sastri.

CII Corpus Inscriptionum Indicarum.

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CSHI The Cambridge Shorter History of India [1934], edited by H. H. Dodwell.

DKA The Purāṇa Text of the Dynasties of the Kali Age [1962], by F. E. Pargiter.

EHD Early History of Deccan, Parts 1 to 4 [1960], edited by G. Yazdani

EI Epigraphia Indica

HAS Hydrabad Archaeological Series

HIPC Historians of India, Pakistan and Ceylon [1961], edited by C. H. Philips.

Hiralal's List Descriptive List of Inscriptions in the C. P. and Berār [1916] by Rai Bahadur Hiralal.

HLI Historical and Literary Inscriptions [1962], by Dr. R. B. Pandey.

IA Indian Antiquary, Bombay.

IC Indian Culture, Calcutta.

ICTWI Inscriptions from Cave-Temples of Western India, [Arch. Sur. Ind. Annual Report]

IHQ Indian Historical Quarterly, Calcutta.

Indica Indica—The Indian Historical Research Institute Silver Jubilee Commemoration Volume [1953], Bombay.

JAIH Journal of Ancient Indian History, Calcutta.

JASB Journal of the Asiatic Society of Bengal, Calcutta.

JASB[NS] : Journal of Asiatic Society of Bombay [New series], Bombay.

JBBRAS Journal of the Bombay Branch of the Royal Asiatic Society, Bombay.

JBORS Journal of the Bihar and Orissa Research Society, Patna.

JBRS Journal of the Bihar Research Society, Patna.

JGJRI Journal of the Ganganatha Jha Research Institute, Allahabad.

JIH Journal of Indian History, Madras and Trivendrum.

JNSI Journal of the Numismatic Society of India, Varanasi.

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JMU	Journal of Madras University, Madras.
JOI	Journal of the Oriental Institute, Baroda.
JOR	Journal of the Oriental Research, Madras.
JPRASB	Journal and Proceedings of Royal Asiatic Society of Bengal, [New Series], Calcutta.
JRAS [London]	Journal of the Royal Asiatic Society of Great Britain and Ireland [London].
JRASB [L]	Journal of the Royal Asiatic Society of Bengal [Letters], Calcutta.
JVSM	Journal of the Vidarbha Saṁs'odhan Maṛḍal [Marāṭhi] Nagpur.
MFV	Dr. V. V. Mirashi Felicitation Volume [1965].
NIA	New Indian Antiquary.
NUJ	Nagpur University Journal.
PHAI	Political History of Ancient India [1953] by H. C. Raychaudhari.
PIC	Progress of Indic Studies [1942] edited by R. N. Dandekar.
PIHC	Proceedings of the Indian History Congress.
POC	Proceedings of the All-India Oriental Conference.
QJAHRS	Quarterly Journal of Andhra Historical Research Society, Rajamundry.
QJMS	Quarterly Journal of the Mythic Society, Banglore.
Review	Review of Indological Studies in the last 75 years [1967], edited by V. V. Mirashi and others.
RY	Regnal Year.
SCHI	Studies in Cultural History of India [1965], edited by Metraux and Crouzet, Forward by R. C. Majumdar.
SI	Selected Inscriptions bearing on Indian History and Civilizations, Vol. I [1965], edited by D. C. Sircar.
S. Ram's List	Some Important Inscriptions of Asoka, The Guptas, The Maukharis & others by Sadhu Ram.
Studies	Studies in Indology by Dr. V. V. Mirashi.
Vidyā	Vidyā—Journal of Gujarat University, Ahmedabad.
VIJ	Vishveshvaranand Indological Journal, Tirupati.
VGA	The Vākāṭaka Gupta Age [1946]. edited by R. C. Majumdar and A. S. Altekar.

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SOCIAL CONFLICTS AND SOCIAL INSTITUTIONS IN INDIA

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The latest development in sociological theory is the emphasis on the integration of society, most prominent among the integration theorists being Talcot Parsons. As Dahrendorf remarks : "It is certainly true that the work of Parsons displays a conspicuous bias in favour of analysis in terms of values and norms. It is equally true that many of those who have been concerned with problems of conflict rather than of stability have tended to emphasise not the normative but the structural aspect of social structure . . . . The integration theory of society as displayed by the work of Parsons and other structural functionalists, is founded on a number of assumptions of the following type :

"1. Every society is relatively persistent, stable structure of elements.
2. Every society is well-integrated structure of elements.
3. Every element in a society has a function, i.e., renders a contribution to its maintenance as a system.
4. Every functioning social structure is based on a consensus of values among its members." [1]

In this integration model very little attention is paid to "conflicts" except "strains". Dahrendorf gives another model of what he calls coercion theory of society which is based on the following assumptions :

"1. *Every society is at every point subject to processes of change, social change is ubiquitous.*
2. Every society displays at every point dissensus and conflict; social conflict is ubiquitous.
3. Every element in society renders a contribution to its disintegration and change.
4. Every society is based on coercion of some of its members by the others."

As the multiplicity of groups in a society always involves some kind of friction and conflict, Robert C. Angell in his book, Integration of American Society, has pointed out : "So significant has been the role of free-standing groups in contemporary life that one is tempted to say that our society is chara-

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cterized by group individualism . . . . . . We cannot assume that the rise of specialized group is disintegrative . . . . Where these groups are in fact harmoniously co-related in our modern communities is exactly the question "[2].

Exactly the same situation prevails in our society. The traditional form of stratification of Indian society on the basis of caste hierarchy, which is sanctified by religion and enforced by tradition, is faced with new forces and challenge due to the declaration in the Constitution of Indian Republic which aims at establishing an egalitarian society. This will create new values which at times threaten to undermine the roots of caste system. Such a situation creates friction, leading to social conflict which cannot be avoided.

Caste in India has served definite functions : it has maintained opportunities for solidarity and mutual support and also served as a status system. The outstanding feature of caste has always been its hierarchical organisation. In the hierarchy of social organisation there are castes of all shades and gradations. Thus, the element of status-prestige is the dominant trait of the system. Within the caste, all the members have supported one another and enabled the needy and the impoverished to tide over their period of difficulty. The hierarchical organisation provided a place to all the castes, which enabled them to live together. Simmel has attemped to explain this phenomena on the ground that reciprocal " repulsions " maintain a total system by creating a balance between its various groups. For example, according to Simmel, conflicts between Indian castes may establish the separateness and distinctiveness of the various castes, but may also insure the stability of the Indian social structure by bringing about a balance of claims by rival castes.[3]

The institution of caste however, has changed in significant ways in the last hundred years or so, but scholars differ about the kind of significance which should be attached to these changes. In the opinion of a few social scientists it is on the way out. Many others point out that while the pollution aspect of caste has weakened, and while there is always a loosening of certain other aspects, caste has shown a tremendous capacity for adjustment to new conditions and its continuance is not threatened in any manner.

Caste consciousness is keen and expresses itself in many contexts. Since Indian social life is mainly articulated through caste, any organisation or association which is formed to further social interests tends to be coloured by caste. Even now it serves as a cementing force for group formation; for within the structure of a caste-oriented society, individual behaviour is largely regulated in terms of the expected and accepted norms of the caste in which the individual is born. His primary loyalties are to his kin and caste members at the local level. Even if he migrates to urban centres, it is essentially along caste lines; if he turns

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a factory worker he returns to his village for traditional ceremonial occupations and, finally, after retirement.

In short, caste represents a close clustering of the members on family-kin-caste lines, especially with reference to birth, marriage, death and financial obligations. This restricts the mental outlook of the villagers, particularly, which is likely to be traditional and caste-bound. This is so even now. Higher castes dominate over low castes in the rural community despite an intensive drive against this by the Community Development Programme.

On the other hand, the Constitution aims at the establishment of a 'casteless and classless' society, which is a contradiction in itself. Every society has to be stratified along some lines with members occupying some positional rank, either in a caste hierarchy as in a rigidly stratified society or in a class hierarchy as in a comparatively open society. Egalitarianism, therefore, does not mean the absence of various levels of stratification. It has to be understood more in its economic context, in terms of equality of opportunity. If non-discrimination between castes has to be achieved, it is only possible by pulling up different caste members together within a class structure where equal opportunity and status prevails for all.

But can caste ever emerge into class ? The roots of the caste system are too deep. Apart from its symbolic value, caste is 'the functioning unit' in the Hindu social system. There may have been changes in inter-caste or intra-caste relationship, but in its functioning caste is as important a factor as ever in maintaining social distance as well as social solidarity.

In a recent study of Jaunsar Bawar by the present writer it was found that in spite of the keen desire of the government to remove the social and economic handicaps of the Koltas, who form the depressed class and provide free labour to their landlords by tradition, it is not possible to remove their disabilities, since the Koltas themselves feel tied down to their landlords by a tradition which is not easy for them to break. So any amount of legislation or governmental effort has not succeeded in removing the disabilities which keep the Koltas in a perpetual state of economic serfdom. This role of caste is inevitable since, in the absence of well-developed inter-groups and voluntary associations, caste has filled an important gap in the life of the people.

Formerly, the caste provided what Iravati Karve has called the 'cultural *gestalt*'. It practically coincided with linguistic and territorial boundaries. But modern communication and transportation have pushed the boundaries of caste from the traditional village extention of the joint family to what are now regional alliances on kindred local units.

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The British anthropologist, Eric J. Miller, has demonstrated in a detailed case study of the Malayalam-speaking region that caste was traditionally, 'a "system of territorial segmentation" in which the bedrock unit was either the village (*desam*) or at most the chiefdom (*nad*). With modern social change, the old boundaries dependent on political cleavages, now became porous, ceasing to mark the limits of social relations with individual castes. This has enabled castes to establish internal bonds of solidarity over wide areas. The last 50 years have seen the growth of a formal regional organisation for practically every caste, with the avowed aim of . . . . . raising the status and prestige of a caste as a whole and free its members from exploitation and victimization by the other castes.'[4]

This increasing solidarity in caste over large geographical distance has led in some way to the strengthening of the caste spirit, which is a new element in it. It has now become *competitive*. Thus the traditional role of caste has now been revised. Formerly caste minimised competition and promoted the spirit of live-and-let-live. A loyalty to its *biradari* or brotherhood meant strength of the system as a whole. But, for caste to become the basis of economic and political enfranchisement and power politics, as well as increasing economic competition, it is bound to magnify all its worst features. This has raised a vast hue and cry against 'casteism'.

Caste, which once expressed social control at the level of a functionally integrated village, now reinforces economic and political conflict, which occurs for the most part within the same linguistic regional boundaries demarcating the newly extended caste alignment. As D. R. Gadgil has very succinctly pointed out : "Social and economic gradations (formerly) roughly extended to the gradation of castes. But now that we want equality and have decided to get rid of the caste system, we face the problem of preserving a live-and-let-live philosophy"[5]. Thus, the associational functions of caste have assumed a greater significance while the institutional functions have receded into the background.

The constitutional provisions guaranteeing specific numbers of government jobs, legislative seats and school admissions to notified untouchable and low castes, have also sharpended consciousness on an enormous scale. This merits greater detail in the discussion on untouchability.

It is difficult to arrive at a clear-cut definition of untouchability. It can better be understood in terms of an ascending scale of social avoidance as given below :

1. against sitting on a common floor,
2. against inter-dining,
3. against admittance into the kitchen,

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4. against touching metal pots,
5. against mixing in social festivals,
6. against admittance into the interior of a house,
7. against any kind of physical contact.

It is a mass phenomenon of group prejudices and discrimination affecting about 60 million people and 429 communities (untouchable caste groups) in India, i.e., nearly 1/6th of the total population according to the 1961 census.

Hutton had divided the disabilities from which the so-called untouchables suffer into two initial categories :

1. that under which they are barred from public utilities, such as the use of roads, tanks, wells, etc;
2. their religious disabilities which debar them from the use of temples, burning grounds and similar institutions.

In addition to the above, there are the disabilities involved in relations with private individuals, such as the services of barbers, washermen, tailors, etc. Even restrictions on their dress and ornaments are also imposed in certain regions.

These differentiations are generally understood throughout the country and learnt by the children. Thus, the Chamar learns from his early childhood that he is excluded from the Brahmin's house, while the Dom knows that he should not make any contact whatever. The hierarchical status of the whole system is clear to every one. The scavenging castes are absolutely segregated even by the Chamar group, which itself is avoided by the rest of the community. Naturally, the proximity of living quarters is another very good indicator of the degree of intercaste acceptance. Typically, the lower catses live on the fringe of the out-skirts of the village or, in some cases, at a distance from it. The same sort of problems appear in the cities.

The problems of the so-called untouchables are, therefore, different in form and substance from those of the scheduled tribes and other backward classes. While educational and economic backwardness is common to all, untouchability and the disabilities arising out of it are problems peculiar to them. At the beginning of the twentieth century the appalling living and working conditions of the untouchable castes aroused human sympathy and public opinion veered round, particularly under the leadership of Mahatma Gandhi, to realise the degrading effects of untouchability. The impact of Gandhiji's influence and work in this area was felt more strongly perhaps after his martyrdom than it was when he was alive.

Vincent Sheean in his book, *Lead Kindly Light*, writes : "At that time, extraordinary events were taking place all over India, testifying to the depth with

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which the departure of the country's father was felt. To most Indians life without Gandhiji was very nearly inconceivable. There were many determined efforts on the part of many thousands of Hindus to get the gates of temples opened to the untouchables. This has been one of Gandhiji's projects, urged upon his compatriots in and out of season as a means of breaking down untouchability. In various parts of India, Hindus of high caste joined with the untouchables in attempts to penetrate the temples and large numbers of them offered Satyagraha, submitted to arrest and imprisonment in this cause. In the result, laws were passed in several provinces opening the temple door to the out-castes, another step was taken towards the abolition of Hinduism's most unlovely excrescence ".

Perhaps the most significant sign of exclusion of the Harijans relates to the use of the water-supply. A scavenger cannot draw water from a common source along with the rest of the upper castes; he must have his own well or stand at a distance for some one to give him water. Not only does this limit the limited water supply for him, whose requirements for personal hygiene may perhaps be the greatest, but he is sometimes compelled to satisfy his water needs from a stagnant pool or even a drain, or may share the filthy and contaminated water with cattle.

Now all these social discriminations and avoidances are prohibited under law. In particular, a special provision under the Fundamental Rights has been laid down in the Constitution for the removal of untouchability. In addition, while various laws have been passed by the State Governments to punish certain kinds of actions involving its practice, the Centre has passed the Untouchability (Offences) Act, 1955, which has made the offence cognisable and punishable under law, uniformly throughout the territory of India.

But it is one thing to legislate and another to implement such legislation. It is true that one cannot now legally discriminate against Harijans in employment and other public dealings. However, the fact remains that they live for the most part as they have traditionally lived, carrying out the dirtiest and most menial forms of work, particularly so in rural areas, since the evil is intricately woven in the social fabric itself.

It is not proposed to go into details of the efforts made by the government to fight untouchability or to render help to the Harijans in this paper. But I would prefer to confine myself to one important aspect of it. The problem of the removal of untouchability belongs more to the sphere of social reform than one to be treated as a matter of administrative and legal meaures. It is more a problem of social distance, group prejudice and certain social attitudes and stereotypes.

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The Renuka Ray Committee was alive to the issue. The Committee was of the view :

" Since Independence, while legislative measures have been introduced and State resources spent on a more extensive scale, the results have not been commensurate with the efforts ... ... The Government of India have sanctioned, during the last few years, large grants to non-official organisations for purposes of carrying out publicity and propaganda against practice of untouchability. While some organisations, which have a long standing record and substantial service to the Harijans, have made full use and proper use of these grants, it is noticed, however, that some organisation of recent origin are engaged mostly in publicity work with the help of Government grants. It is a matter of common knowledge that the programme of publicity is not a visibly established programme like that of welfare services. Further, since the results of such publicity are intangible, it cannot be stated with certainty that the grants through these organisations are achieving their objectives. "

The Renuka Ray Committee has put it rather mildly. In actual practice, the publicity indulged in is more in the nature of self-publicity rather than any attempt to high-light the evils of untouchability and thus bring about a change in the attitude of the masses towards the Harijans. Similarly, provision for additional facilities like separate schools, crafts training centres, housing colonies and the like will not by themselves serve to eradicate the evil.

In the first place, this approach will encourage segregation, isolate the Harijans and thereby perpetuate the evil of untouchability. Secondly, unlike the tribals who are mostly concentrated in certain defined areas, the Harijans are spread all over the country. Even on grounds of expediency, it is not feasible to accept this principle of segregation and spread it throughout the length and breadth of the country. The real problem is that so long as the Harijans remain as " untouchables ", their mobility in every field and walk of life is bound to be restricted. Hence the problem of untouchability is primarily a question of social reform; other measures can only serve as palliatives.

In short, it needs a new outlook and a complete change in social attitudes. Perhaps compulsory education at the earlier stages in schools, where students of all castes are fully admitted, and abolition of the system of calling welfare schemes, such as opening schools or digging of wells, for the use of Harijans, will create a better climate for the integration of scheduled castes with the upper castes. Even the reservation of seats for the scheduled castes in the legislatures and various government services is bound to prove harmful from a broader point of view, since it will perpetuate, more or less, the existence of the so-called depressed classes; for they will always feel insecure if the existing privileges are taken away from them.

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Thus, an under-privileged social class with constitutional safeguards and certain benefits guaranteed to it becomes segregated and social distance from other castes remains as great as before, although from a legal and constitutional point of view such a distance may not exist at all.

The only possible solution that we can suggest is to bring about a social revolution which will remove the traditional social distance between the higher castes and Harijans. This is possible by creating pressure groups through the formation of interest groups, which cut across traditional occupations. In this connection it may be profitable to follow the basic concepts underlying Gandhian economics which emphasised the de-centralisation and diffusion of capital by encouraging cottage and home industries and creating a market on co-operative basis for the finished products of these industries. These occupations should be at complete variance with the traditional occupations of the Harijans. This will help in reducing prejudice, which is incidental to their low calling. The Harijans function under a double handicap; first, social prejudice, which has resulted in pollution complex, giving them the lowest place in the caste hierarchy; second, low order of the traditional occupations of the Harijans, which creates prejudice against them and also social distance. If we can succeed in providing them with alternative occupations, apart from greater educational facilities which are available to them now, the consequent change in their economic status is bound to have its own social repercussions, which will considerably reduce social prejudice against the Harijans because of the menial work done by them as a result of their hereditary calling.

Another significant type of Social conflict, which has great social importance is inter-group tension between two communities, Hindus and Muslims, which is popularly known as 'communalism'. In the wake of recent 'communal' riots in Ahmedabad, there has been considerable thinking on this sudden spurt of violence and serious efforts are being made to probe into the causes of recurrence of communal trouble at frequent intervals in our society. If we can analyse the phenomena scientifically and objectively, it may be possible to find out ways and means to prevent recurrence of such riots in future. The Ahmedabad communal riot cannot be regarded as an isolated occurence. In recent years there have been many such serious cases of communal rioting, in Malegaon (1967), Aurangabad (1968), Indore (1969) and Ahmedabad (1969). It is surprising that while the whole Indian social structure is in the nature of a highly diversified and stratified organisation, which has allowed various castes, creeds and religions to co-exist throughout her history to constitute a unified whole inspite of so many diversities, yet this harmony is suddenly ripped apart at frequent intervals like a jarring false note when one is lost in attentively listening to a harmonious melody. It is, therefore, obvious that there must be deep-rooted causes which

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are inherent in our social and cultural milieu that create such tensions leading to violent conflicts.

It is no use blaming the Muslim community for fomenting communal trouble in the country. The Indian Mohammedan provides us with a unique phenomena. He is essentially the product of Indian soil and our cultural heritage. It may be that he is the heir to Arabic influence, stemming from the Koran and its ideology. But what needs to be emphasised, in addition, is the Indian intellectual, social and customary contribution, which gave its imprint to Islam in India. Otherwise it would have remained only an exotic and foreign faith in India. No Arab, for example, would have approved of the celebration of Hindu festivals like Holi and Diwali, which were observed with great pomp and enthusiasm in Mugal courts from Akbar's days to the downfall of Mugal empire. Mystical elements in India founded link and response in Persian thought; the Sufis from Persia provided a bridge between Indian and Islamic thought and practice. Their centres, like that of Salim Shah Chisti at Ajmer, were places of resort and pilgrimage; their methods were peaceful and their appeal was to the heart. In the inter-play of Persian and Indian mysticism Indian Islam found its soul. It was the Mohammedan weaver poet, Kabir, who proclaimed that the same God reigned in mosque and temple alike. A further consequence of this inter-change of ideas has been the Indian Muslim tradition of tolerance. After the early exchanges and acts of ferocity the Muhammedans, influenced by their Indian environment, settled down to live and let live on Indian soil. In pre-Mugal Bengal, in the 15th Century Deccan and in Gujarat there were remarkable cases of cultural syncretism. All over India there was a general acceptance of the principle of coexistence with the result that the Muhammedans in India became a community with specific characteristics rather than a collection of individuals or groups. There was in this community an element of separateness, which also marked its uniqueness, the Islamic heritage; at the same time there was an element of identity, of oneness with the country. Thus an Indian Muhammedan became a different person from his counterpart in Persia, Arabia or Turkish lands. While proud of his Islamic heritage, he dug his roots deep in the Indian soil and took to it as the land of his choice and upbringing. But Indian Islam, while being remarkable for its identification with India, never ceased to be separate from Islamic tradition. It maintained a certain degree of separateness, which at times assumed strong and even violent resentment against majority community under political pressure.

The partition of India in 1947 and the sudden outburst of violence in the wake of Independence created a feeling of insecurity among the Muslims. But the Government's attitude and policies, to a certain extent succeeded in creating an atmosphere of security and peace, which was clearly demonstrated at the time of Pakistani aggression when the Muhamedan minority stood solidly behind

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the nation and Muhammedan soldiers fought shoulder to shoulder with Hindu soliders.

At the same time it cannot be denied that a feeling of separateness combined with insecurity prevails among the Muhammedans. This is partly connected with our relations with Pakistan. Pakistan never hesitates to give a highly coloured account of any incident affecting the Muslims reported from India. The constant hostile publicity in Pakistan by blowing up of minor events into major ones, is bound to be very embarrassing for Indian Muslims. It provides just the handle needed by the Hindu extremists for casting doubt on the Muhammedans for their good faith and loyalty. At an annual Convention of an important Indian political party, held very recently at Patna there was an open reference made to Indianisation (भारतीयकरण) of the Muhammedans. There is, therefore, no doubt that the Partition of India has put the Muhammedans on defensive.

However, at mass level differences between the Hindu and Muhammedan communities have been nominal. A detailed study of the history of the Marathas, Rajputs and the rulers of Delhi would disclose that the ideological differences of their respective religions did not stand in the way of their co-operating with each other against their co-religionists. The internecine wars of Bahmani Sultans could be fought only with the help of Maratha Sardars and the Rajputs did not hesitate to associate with Mugal emperors against rebel Hindu Marathas. Thus secularism, which is the basis of Indian Constitution, is in keeping up with this historical tradition. It is not anti-God nor anti-religion. It grants full freedom as a fundamental right to the practice, profession and propaganda of all religions. All religions are entitled to equal respect in India.

Again the talk of the establishment of *Hindu Rashtra* is of comparatively less significance, if not meaningless, since the Hindu society is so differentiated culturally and even politically that the emergence of a Hindu state could only be described as a dream. But the real danger lies in the fact that the Hindu sentiments can be mobilised to be directed against a minority even on religious grounds. This possibility is a challenge to leaders of both the communities. It is not enough for secular-minded Hindus to fight the forces of communalism among their co-religionists. The leaders of Muhammedan community have also to pacify the Hindu suspicion of Muslim separatism. An equal effort for the secularisation of their attitudes has to be made by the Muhammedans themselves to bridge the gulf that has historically separated the two communities. It is only on these lines that national integration can be brought about and more permanent values created.

Reservations and other safeguards cannot provide any solution to the problem of backward groups and minorities. They would merely depress the

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already low standards of education and administration, put a stamp of inferiority on those who benefit by these arrangements and create a vested interest in backwardness and separatism. What is necessary in such a case is not reservations but special opportunities for making the grade without compromising on standards and without allowing discrimination on grounds of religion. Such an approach can be successfully adopted if all the political parties agree to treat the problem of national integration as one, which, like the problem of untouchability, cuts across party lines. A progressive and modernised State cannot be built up if a large number of its citizens are demoralised and have no sense of stake in its survival or progress or prefer to live in comparative isolation.

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TEACHING OF SOCIOLOGY IN REGIONAL LANGUAGES A CASE STUDY*

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Introduction :

Before independence, the issue of medium of instruction — particularly in the institutions of higher learning — was not debated. The educational set up was based on the British model modified for colonial administration. The structure and functions of the educational institutions were largely geared to achieve these goals conceptualized and set forth by Macaulay. Macaulay's blueprint of the system of higher education in India was designed to train and develop a class of individuals who would be interpreters between the English and the millions they governed, and the British system of education in India produced, over several decades, a class of persons, Indian in blood and color but English in taste, in opinions, in morals, and in intellect. English was given primary importance; it was the language of instruction in high schools, colleges, and universities. However, some efforts were made, notably by Tagore and Mahatma Gandhi, to establish the regional languages as medium of instruction. The need for carrying out the local and regional administration through the local regional language was emphasized. Notwithstanding some scattered instances of success in this direction, English continued both as the language of instruction in high schools, colleges and universities, and as a major vehicle of local, regional and central administration; it enjoyed the status as the language of the elite.

After independence, the goals of the educational system have been changed. We are interested in imparting training and skills which would serve the needs of the masses and provide adequate opportunities for the development of a technologically advanced and meritocratic nation. While there is an almost universal agreement in the broader and larger goals of education, we have been passing through a rough terrain of confusion, sentimentality, and regionalism in the matter of medium of instruction in the institutions of higher learning. The local languages have been accepted as the proper and efficient medium for educating the masses upto the secondary and high school levels. There is some

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disagreement regarding the provision of adequate facilities at the secondary and high school levels for those who would continue their education beyond high school, for those who would presumably provide the manpower needed to co-ordinate the inter-state matters and for those who constitute a small but important section of the gifted individuals expected to guide the nation in its scientific and technological development. In spite of this sort of disagreement, the issue of medium of instruction at the secondary and high school levels is not a thorny one, and most institutions impart instructions through the local languages at the secondary and high school levels.

Medium of Instruction in Universities :

There is no agreement and universal policy and practice concerning the medium of instruction at the post-high school level. However, it is suggested by several experts — particularly in the Radhakrishnan Report and the University Grants Commission Report on the Medium of Instruction, that English be replaced, as early as practicable, by an Indian language, although English be studied in high schools and in the universities in order to keep in touch with the living stream of ever-growing knowledge. It is also recommended that the students at the higher secondary and university stages be made conversant with three languages, namely, the regional language, the federal language, and English. Many universities have planned a program of change over in the medium of instruction. I should not enter into the details of the programs of change-over in the various universities here. However, the following table, prepared from the available data in the Hand Book of Universities in India (1963), shows a remarkable trend of a change-over from English to regional languages and Hindi. It should be noted that since sociology as a major subject is included in the Faculty of Arts or the division of humanities, the distribution of universities by medium of instruction is shown separately for the B.A. and M.A. levels. The picture of a change-over in medium of instruction is somewhat different in other branches.

Table 1 : Distribution of 56 Universities by Medium of Instruction and Examination at B.A. and M.A. levels separately.

Medium of Instruction and Examination

	Regional Language and Hindi as optional language	*Regional Language and Hindi and English as optional languages*	*English*	*Total*
B.A.	14	26	16	56
M.A.	7	15	34	56

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These data, given in Table 1, show that over two-thirds of the universities have had accepted by 1963 the regional language as a medium of instruction and examination at the B.A. level and about forty per cent of the universities have had accepted by 1963 the regional language as a medium of instruction and examination both at the B.A. and M.A. levels. Second, all universities that have accepted the regional language as the medium of instruction and examination have also accepted Hindi as an optional medium. Third, a majority of the universities that have accepted the regional language as the medium of instruction and examination have also accepted Hindi as well as English as optional mediums. Finally, the trend for retaining English as the medium of instruction and examination is stronger at the master's level than at the bachelor's level.

Issues Concerning a Change-over in Medium of Instruction :

A trend toward accepting the regional language as the medium of instruction and examination at the B.A. and M.A. level is apparent. However, any program of change-over in the medium of instruction and examination at the post-high school levels raises several issues-concerning the following matters :

1. Availability of adequate resources to impart instructions in the regional languages and their impact on students' performance. The resources in this category refer mainly to qualified teachers and examiners, who are proficient in the regional languages, and efficient tools, namely, text-books, standard works and references, research journals, and so on.

2. Difficulties involved in developing adequate translation works. The difficulties in this category refer to the developmental stage of the regional languages, scarcity of trained persons to translate the standard works in regional languages, difficulties and disagreement regarding the translation of the technical terms in regional languages, and costs involved in publication of the translated works.

3. Inter-state, inter-university and international contact and migration of teachers as well as students.

4. Knowledge of a federal language (presumably Hindi) and English as supplementary or library languages.

The above matters are inter-related, and the question of efficiency or quality of education is very closely related to all of them.

I shall not try to discuss these matters here, but I shall use the above classification as guidelines in my description of the experiences in a change-over program and planning in teaching Sociology in Gujarati at the Gujarat University in the following pages.

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A Change-over in Medium of Instruction at the Gujarat University :

The Gujarat University has pioneered the teaching of Sociology in Gujarati at both the under-graduate and the graduate levels. English and Hindi are allowed as optional mediums, but most students and teachers use Gujarati. The transition from English to Gujarati has been gradual, but controversies and legal battles have frequently clouded the change-over program during the decade.

The change in medium of instruction and examination was introduced initially in the first year of college and gradually extended to graduate and post-graduate levels. Most of the teachers in the affiliated colleges and in the University Department were Gujarati-speaking or had at least some working knowledge of Gujarati. But the acceptance of Gujarati as the medium of instruction brought about some restrictions in recruitment of teachers and appointment of external paper-setters and examiners. The panels of internal and external examiners in sociology have been more or less constant over the last few years. The referees for M.A. theses have to be appointed from the same limited pool of Gujarati—speaking external examiners instead of number of non-Gujarati scholars involved in research activities directly related to the students' theses. With the expansion of educational facilities, several times more students opt now for Sociology. This means that the colleges need to recruit more and more teachers in Sociology who are proficient in Gujarati. Most of the new teaching members in colleges are those who have obtained their training in Sociology with Gujarati as a medium of instruction and examination, who are not adequately proficient in English, and who have obtained their degree certificates mainly by relying on their class notes rather than perusal of original material in English. One deplorable outcome of this situation has been that the quality of the teachers has been gradually deteriorating to the extent that the post-graduate students have difficulties in using course materials and reference works published in English. Similarly, the students do not benefit much from the extra-mural lectures by the non-Gujarati scholars. In an inquiry of 140 students in Sociology, 119 students reported that they attended lectures delivered in Gujarati and could follow the contents of the lectures very well, but only 2 out of 59 students who attended lectures delivered in English reported that they could follow the contents of the lectures satisfactorily while the rest mentioned that they understood the least of the delivered contents. Thus, a major limitation of the regional language as a medium of instruction and examination is that the system does not get the benefits of the scholars who do not speak the regional language.

The university did not wait for the production of text-books in Gujarati. The late Maganbhai Desai, the Vice-Chancellor of the University believed that " It is not only futile but also highly wasteful and even self-deceptive to wait for the preparation of text books for introducing this much needed reform in

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our education ". Initially, there was not a single text-book of Sociology available in Gujarati, but eventually the principle of free enterprises yielded sizable and competitive crop of text-books and about 40 text-books are currently available on various topics in Sociology. Lest any one should be over enthusiastic in interpreting this as a success, I must mention that except for a few translated works (Mac Iver's *Society*, Ginsberg's *Sociology*, Hutton's *Caste in India*, and Srinivas's *Caste in Modern India and Other Essays*), there is hardly any publication of an original nature, research reports, reference manuals, or a research journal in Gujarati. It is difficult to comment upon the quality of a large number of text-books of Sociology published in Gujarati, but my own subjective feelings are that most text books are sub-standard. The non-availability of half-baked quality of available books in Gujarati leads to the unavoidable conseuqence that most students rely on their class notes. In my inquiry, 80% (112) students reported that they rely on their class notes and about 50% (74) refer to even the available books in Gujarati. Only 11 out of 63 M.A. students and only 13 out of 77 B.A students reported that they refer to Sociology books in English. This is supplemented by the reports of the examiners that many candidates reproduced the class notes without supplementing the required details from the text-books. In short, the acceptance of Gujarati as a medium of instruction and examination has led most students in Sociology to rely on class notes. This situation is clearly bound to limit the spectrum of information and training received by the students.

As mentioned earlier, a few books have been translated in Gujarati, and it may be assumed that in course of time sufficient number of books of high quality will be published by the specialists proficient in Gujarati as well as in English. But, mere translation of standard books is not sufficient to keep pace with the rapid development in Sociology. The process of translation and its publication is very slow and costly. The works which may be considered standard and adequate for the use of students at a given level may turn out to be somewhat obsolete at the time when they are published in Gujarati. Besides all translastors do not have the ability to produce the translated work in its real spirit. Thus, while some usefulness of translation work should be recognized, it will be foolhardy to consider any program of translation as adequate for the successful implementation of a change-over in the medium of instruction.

There is not a single research journal of Sociology in Gujarati. The teachers as well as the students are expected to read the articles published in English journals, but the limitations of language proficiency result in a situation where most journals are read by the least number of students and teachers.

The Gujarat University has, from the very beginning of its program for a change-over, concentrated its efforts in preparing the scientific terminology

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in Gujarati. A fairly adequate compilation of sociological terminology is available in Gujarati, but to our great dismay most of the substandard text-books published in Gujarati have not used this commonly agreed and workable terminology and have instead attempted to coin their own terminology. While we should not discourage any revison in scientific terminology, it seems to me that such sporadic efforts lead to confusion and misunderstanding among the students who refer to such text-books with variation in Gujarati terms of important concepts.

One of the major limitations of the regional language as the medium of instructions at the post-high school levels is that the inter-state, inter-university and international contact and migration of the students as well as the teachers is obstructed. Although this is not an inherent limitation of using the regional language as the medium of instruction, in reality most individuals over a long period of time tend to lack in an efficient use of the language they are not required to use frequently. If we accept the need for retaining English as a library language and if we retain in our curricula adequate provisions to guarantee a workable knowledge of English as a library language, I think we would be able to implement our goal of a change-over in the medium of instruction more successfully.

In my inquiry, nearly 58% (81) students totally agreed, 39% (55) partially agreed, and only 4 students disagreed with the statement that it is necessary to know English as a library language. Further, 60% (84) totally agreed, 31.4% (44) partially agreed and only 8.6% (12) per cent disagreed with the statement that under the present circumstances, the knowledge of English is necessary to attain adequate proficiency and training in Sociology, although a majority of the students are not at the moment proficient in English. Several students stated that it is easy for them to grasp the subject in their mother-tongue; that the medium of instruction should be Gujarati; that since the medium of instruction at B.A. level is Gujarati, it is not desirable to teach sociology in English at M.A. level; and that the latter situation creates difficulties and brings frustrations among the students. However, in view of the paucity of Sociology books in Gujarati at the post-graduate level and deficiency in their competence in English, they are faced with certain handicaps. They think that their chances of employment are limited; that they suffer from inferiority complex and are aware of their inability to compete at all-India examinations; and that their chances of migration are very limited.

I have so far pointed out the shortcomings difficulties and problems of a change-over program. However, this should not be interpreted as indicating any total failure of our plan and program to impart instruction in Gujarati. There have also been some successful outcomes. Since the feeder systems for our higher educational institutions impart completely and rather successfully instructions in Gujarati, the Gujarati medium at the post-high school levels has attracted

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a large number of students to opt for Sociology as a major or minor area of their interest. The discussion of sociological issues which are closer to our day-to-day experiences becomes easy and draws a large number of praticipants. Although there are some difficulties in transfering the meanings of some technical concepts through Gujarati, the general understanding of the subject is by and large enhanced. In my inquiry, 123 out of 140 students mentioned that they could follow the subject easily in Gujarati. There is now an attempt to produce a series of brief and critical studies on various topics in Gujarati. The Gujarat University has recently planned for the publication of booklets, to be originally written in Gujarati, on the works of several selected theorists and important topics in Sociology. Such efforts, rather than the publication of text-books tailored for examination purposes and motivated by monetory considerations are bound to help the students in imbibing the major thrusts of the sociological literature. It seems that under the present circumstances of limited availability of resource materials in Gujarati, coupled with inadequate training and interest in English, Most students and some teachers fail to use English as a library language and supplement their understanding of the subject obtained in the class-room by an analytical perusal of the material available in English. Lest any one should think that the disinterest of the students as well as the teachers in making a fruitful use of our library facilities is a direct outcome of our choice of Gujarati as a medium of instruction, I must emphasize that the Gujarati medium has not created this situation but has only contributed to the existing situation.

Conclusion and Suggestions :

Basically, the theory of imparting instruction in the regional language at all levels of our educational system is sound, but in a multi-lingual nation like ours, there are some factors which demand a guided and gradual program of change-over. While a watertight schedule of a change-over may look outwardly successful, the forced situation seems to contribute to an inadvertent compromise with the quality of education. Like in many branches of knowledge, there is an anormously vast amount of classical and contemporary literature on Sociology available in English, and an increasingly large amount of literature in the form of books, journals, and reports of empirical studies are being published each day and month of the year. We cannot hope to mobilize either the manpower or monetory resources to select and translate or render abridged versions of so many publications of vital importance to several sub-branches of our discipline. We cannot hope to maintain or raise the quality of education if we attempt to follow any tight schedule of a change-over. We must have patience and plans for an accelerated but gradual and natural growth and maturity of our discipline in our regional language. It is easier said than done that we recognize the importance of English as a library language. Our educational system is too closely

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associated with the formalized structure of our examination system and we should not allow the human frailties to make any inroads on our efficiency. In the words of M. S. A. Rao, "the educational system is the chief agency to maintain efficiency, to develop human resources and to foster the desired values and to achieve set goals. Any inefficiency in this feeder system, will have an adverse effect on the nation as a whole."

I have tried to review the situation prevailing at the Gujarat University and I am inclined to believe that somewhat similar situation is likely to prevail at other Universities where medium of instruction is a regional language. I would like to offer the following suggestions to avoid some of the difficulties experienced in a change-over program.

(1) English should be accepted as a library language and adequate steps should be taken to ensure that the teachers as well as the students make an efficient use of the materials available in English.

(2) A central bureau of University publications be established for each regional language accepted as the medium of instruction. Its work should be to organise production of translation and abridgement of standard books and original works in regional languages. A Sociologists' Digest of the respective important articles be published periodically in the respective regional languages.

(3) A scrutinising committee be appointed to review books published in the respective regional languages by private agencies.

(4) Periodic evaluations of the change-over on the quality of teaching the subject be made by an expert committee.

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SOCIAL STRATIFICATION AND NON-VIOLENT SOCIAL ORDER

A Case Study of Village Community in Rajasthan

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I

Social stratification is a system of ranking involving relations of high and low. These relations of superior and inferior statuses between different units of ranking are regulated by a set of norms. Such relations may not exist only in an absolutely classless society, however, such a society would be only an ideal one, if it existed at all. Stratification system based on certain principles and criteria patterns or 'orders' social relations between the constituent units of a society. Here we can observe that stratification involves value-system, power structure, ascription and achievement principles, patterns of conformity and deviance and reward and punishment attached with them (Parsons : 1954, 68–69). Such a definition of stratification makes provision or scope for 'inequalities' based on superior and inferior statuses. The superiority and inferiority of statuses is understood by the 'functionalists' as a prerequisite for the very existence and well functioning of society.

The keynote of functional approach to the study of stratification is that functional differentiation is inevitable for differential intent and ability. The logic behind this assumption is that one person cannot perform all or most of the functions in a society. Therefore, different persons perform different roles and duties. These roles and duties have a different value attached with them, and therefore, the performers are differentially evaluated and accordingly rewarded (Davis Moore : 1945, 1953). Thus, the quintessence of the functional theory is that social hierarchy 'is functional', inevitable and basic for the survival of mankind.

But on the contrary the dialectical approach is 'monodimensional' (Marshall : 1963) deterministic or 'dimensionistic' as Jackson (1968 : 14–24) calls it. The basic tenet of this approach is that economic interests are basic to all other types of relationships, social, cultural and political. There are two classes, that of the bourgeoisie and the proletariate. The interests of these classes

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clash with each other, therefore, there is a class-struggle between the two. This class struggle leads to revolution and radical transformation of the inequalitarian stratification system (Dahrendorf : 1959 writes about Marxian theory on class).

There are others who do not observe a rigid distinction between the two approaches (Jackson : 1968 : 14–24). Jackson associates functional approach with what he calls 'propositional theory'. He lists Lenski's theory (1966) of this nature. The dialectical approach is nearer to what he names 'dimensionistic' theory. Dahrendorf's conflict theory is closer to this approach. Propositional theories provide causal explanations and they are empirical. In dimensionistic theories, the explanations contain finalistic or teleological elements which do not permit a clear observation of cause-effect relationships or results. Jackson refers to Parsonian theory containing finalistic elements and, therefore, unscientific. Dahrendorf uses 'power' both as cause and effect of social stratification. In functional or 'integration' theories explanations of a similar kind are found. The keynote of Weber's (Weber : 1947) theory of stratification is also power. Lenski has provided a theory of social stratification based on power and privilege.

Thus, the distinctions between the two approaches are of a subtle nature, and therefore, the two may not be considered as opposites. They should be applied as tools for understanding specific situations and structures simultaneously. The same unit of ranking may have dialectical relations with other units in some respects and it may not exist in other respects. Thus, one has to sort out the network of social relations in this particular way. It is in this way we can, perhaps, understand more deeply our existing social structure. But this does not mean that this is an attempt toward a 'synthesis' of the two approaches. The two approaches have their theoretical and analytical relevance separately. Ours is an attempt to analyse the rural stratification system keeping the basic tenets of a non-violent social order in mind and applying the two approaches together but in a selective way.

II

Before coming to the corroboration of the findings of my own study alongwith that of the others, it is necessary to highlight the concept of non-violence and its association with the concept of stratification. Non-violence is considered more as a moral and ethical concept, a guide for personal behaviour and performance. Recently, it has been used essentially as a 'social' concept (Unnithan and Singh : 1969) meaning thereby social justice, equality, freedom, non-exploitation and absence of physical violence and presence of peaceful settlement of mutual differences and disputes. A non-violent social order emphasises

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not only 'ends' based on an egalitarian philosophy but also non-violent 'means'. Achievement of a non-violent society through violent means demolishes the basic foundation of the conception of a non-violent social order. Marx also visualized a non-violent society but the means which he advocated to be applied were violent. Same could be said today about the philosophy enunciated by Mao in China.

It was Gandhi (1965) for the first time who put equal emphasis on the purity of both means and ends. Gandhi's conception of Ram Rajya was synonymous with a non-violent social order. This was a society which Gandhi cherished and wanted to develop as a new social order. This was to be nourished through a peaceful revolution. Prevalence of hatred, exploitation, bureaucratization and use of force and violence consituted a violent society according to Gandhi. On the contrary, Gandhi wanted to remove certain elements, as untouchability, exploitation and brute force and bring certain things not through force but by a change of heart and mind of the people. It was, in fact, a total transformation of institutional networks and value premises. A change of values and institutions through pursuasion, appeal and other means of liberal media is not a personal or individualistic way of change, it has wide democratic connotations and implications for peaceful radical transformation at societal level. Such a transformation has long-standing consequences compared to that of the transformation through the use of force and violence.

Gandhi stressed the development of a synthesis of personal and social conceptions of non-violence. He thought that practising of non-violence at individual level would certainly create a genuine climate for generating social non-violence. He believed that adherence to the principle of non-violence in personal dealings would compel people to think in terms of societal non-violence. At the individual level, Gandhi put emphasis on certain qualities, such as, simplicity, ascetism, truth, non-violence and trustworthiness, etc. At the social plane, the qualities characterised by Gandhiji portrayed the picture of a society which he imagined and wished to realise. Thus, Gandhi combined individual approach with that of institutional approach (Singh : 1969).

Gandhiji thought of a classless and stateless democracy of autonomous village communities, where coersion, exploitation and centralization of wealth were absent. It was a co-operative and constructive society. Conflicts could be resolved through the spiritual plane of love and brotherhood. Ganhdiji wanted that Zamindari did not exist there, as this would abolish both capitalism and exploitation. The land should belong to the actual cultivator, and no cultivator should possess more land than that required to fulfil his family obligations. Gandhiji did not believe in class-conflict to achieve this 'Sarvodaya' based

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society, rather he was for class-collaboration and class-co-ordination to realise the goal of classless democracy.

Gandhiji's entire thesis was that of changing of mentalities of the Haves. He said that if the Zamindars changed their mentality, there was no need to expropriate them, and if they worked as trustees of peasants and cultivators. His conception was of formation of a society of family-like relations. Thus it was a theory of pure humanism accompanied by pragmatic considerations and rational values, which if could be realised would have more enduring and long-standing results than what a violent revolution could have brought in Indian society. This is so becuase Gandhi did not advocate non-violence compromising with evil and violence.

Now it is clear that Gandhiji wanted to revolutionise thought system and motivational orientations, particularly of those who were superior economically and socially than the bulk of the expropriated proletariates. Gandhiji believed in a slow, peaceful progress and, therefore, visualized that the abolition of caste system in terms of functional groups was not desirable, as the existential Indian situation needed these groups functionally fruitful. Gandhian economics was, therefore, planned in such a way that it strengthened the traditional village economy. Gandhiji thus talked of a ' levelling process ' to reduce the abundant inequalities.

Gandhi's philosophy of non-violent social order (in terms of Ram Rajya or Sarvodya) is not very well defined. This lack of theoretical precision creates a number of problems for a scientific analyst. Gandhiji advocates, for example, continuance of ' functional groups ' in society, but does not spell out which functional groups would be there, what functions they would perform and what relations would hold with each other ? Again the very existence of functional groups encouraged or enhanced inequalities. A trader, for example, is functionally necessary, his existence is necessitated, but the extent of porfit he would extract is not controlled, the result is that he is left free to exploit under the garb of his functionally necessary existence. The logic may apply to other groups as well.

Secondly, Gandhiji advocated revolutionalization and overhauling of motivations, hearts and minds of the people through the spirituality of love and brotherhood. No doubt Gandhi was a charismatic perosnality and he could routinize his charismatic charm during his life tenure to a great extent, but this was not a permenent social mechanism through which his gospel could be materialized. Gandhi did not leave behind him an army of staunch dedicated followers who could be as charismatic as he was. In fact, the bourgeoisie got concealed support from Gandhian ideology, as he did not change their hearts and minds

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in reality. Moreover, change of heart is not measurable even in a rudimentary and approximate quality or quantity or both.

Thirdly, Gandhian theory of action was that it did not have a legal sanction to get it rigorously implemented. The time target was undefined. The exactness was lacking. As such Gandhian philosophy remains paper policies just like the Directive Principles of State Policy in our Constitution.

Fourthly, we can not root out inequalities and discrimination if we have functionally interdependent groups as the functionalists put it. Therefore, non-violent society both at the individual and social levels in its absolute form is only a myth, impracticable and super-ideal. If this is so, we can not overlook the inevitability of conflict and its resolution sometimes by force and coersion and sometimes by peaceful settlements and negotiations depending upon the situations and the nature of parties involved.

Finally, we notice some contradictions and inpracticable propositions in Gandhian ideology. Gandhi suggests voluntary restriction of wants. We do not find evidence in human history with a few exceptions that men restrict their wants. Again Gandhi says that all men should get equal remuneration irrespective of their work and telent. We know that all works are not equal, some are strenuous, others are pleasant. Gandhi thinks of an altruistic society in which people sacrifice for the weaker sections (Oommen : 1969). But this proposition also does not sound strong as a rational way for distributive justice. Distinctions of the propertied and propertyless persist even in Russia and China. As we have mentioned earlier that Gandhi visualizes the emergence of a classless society, but his endorsement of the Varna scheme negates it at all. Acceptance of Varna scheme leads logically to stratification (ranked in terms of higher and lower units) which in turn restricts mobility for some and permits for other. Thus, Gandhi's plea for an egalitarian society is obversed by his acceptance of the Varna scheme.

III

Stratification is inevitable and as such it essentially involves a certain degree of social violence and also personal and physical violence. This is because that higher ascriptive status rank of a person, family or group provides higher possibility even for an increase in their status through achievement in different asepcts of life. This statement does not imply that there do not exist status distinctions between members of the same caste or sub-caste. There may be a perfect coincidence or correlation between caste, class and power positions held by a group or family, there may be cleavages, but a considerable amount of ' summation of roles ' still persists. Composite status ranking given in table one supports this proposition.

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Table–I

COMPOSITE STATUS RANKING OF DIFFERENT CASTES

Caste	*Lower* (3–4)	*Middle* (5)	*Upper Middle* (6–7)	*Upper* (8–12)	*Total*
Upper	—	7(3.1) (3.0)	81(36.2) (28.4)	136(60.7) (52.3)	224(100.0) (20.5)
Intermediate	39(7.8) (12.3)	160(31.9) (68.7)	183(36.4) (64.2)	120(23.9) (46.2)	502(100.0) (45.8)
Lower and 'untouchable'	278(75.3) (87.7)	66(17.9) (28.3)	21(5.7) (7.4)	4(1.1) (1.5)	369(100.0) (33.7)
Total	317(28.9) (100.0)	233(21.3) (100.0)	285(26.0) (100.0)	260(23.8) (100.0)	1095(100.0) (100.0)

Status score 1 to 12
First quartile at 4
Second quartile at 5
Third quartile at 7

Lower status scores 3 and 4
Middle status score 5
Upper middle status scores 6 and 7
Upper status scores 8 to 12.

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We admit differentiation of traditional institutional structures. Emergence of secular jobs, newer educational pattern and increased rate of migration and urbanization have helped this process. But these changes have not substantially resulted into decentralization of power and mitigation of cumulative inequalities. This is due to the resourcefulness of the privileged, by which they maintain status quo and manipulate the new attributes of higher prestige and power according to their interests and predilections. The non-privileged thus have remained basically down-trodden and backward.

In the six villages (Sharma : 1968)* out of total male workers 20 per cent have taken up secular jobs. Among the upper caste workers 46% have taken up secular occupations, whereas 11.6 and 9.3 per cent workers are engaged in secular jobs from among the intermediate and lower castes respectively. This shows not only occupational diversification but more significantly the differential occupational mobility which the different castes have witnessed during the past three decades. This differential character of occupational mobility has come in the way of equalitarianization or distributive justice in the villages under our study. The prestigeous jobs are being virtually monopolized by the ex-privileged castes. There are, no doubt, 'new bases' of status, but the new bases are so costly that the non-privileged sections are unable to afford the cost of achieving them. The resourcefulness of the privileged castes hinders the process of egalitarianism.

In the six villages all the 29 graduates and 74 matriculates are from among the Brahmins, Rajputs, Banias and Jats. The first three are twice-born castes, whereas the Jats are a major land-owning and peasant caste. This pattern of education also reveals that what is achievable is not available equally to all kinds of persons and groups. Monopoly by the privileged groups and families over education further strengthens inequality of status and rank.

Similar pattern is found in regard to distribution of positions of power and influence. The upper castes constitute only 18 per cent of the total households, but out of 76 influentials and key individuals in the six villages 41% are from among the upper castes. On the contrary, the lower castes compirse of 32 per cent of the total households, but have only 4 per cent key individuals out of the total 76 influentials. In the six villages all the Sarpanches (President of the Village Council) so far have been elected from among the Brahmins, Rajputs, Charans and Jats. Status and power conflicts and rivalries are not pronounced between the lower and higher groups but they have been of a intra-class and intra-caste character.

But we can not ignore the beginning of the processes of change in the traditional social stratification. They have gained a little bit of base in the village

* K. L. Sharma 'The Changing Rural Stratification System : A Comparative Study of Six Villages in Rajasthan' (unpublished Ph.D. thesis).

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community. The twin processes of proletarianization and bourgeoisiefication have simultaneously increased and decreased economic inequalities and consequential social status distinctions. These processes essentially imply mobility in an abrupt way, from high to low and from low to high without touching the intermediate levels of stratification.

About 15 families of Rajputs, Brahmins and Charans have been reduced to the status of landless, manual workers due to the abolition. On the contrary, 30 families of the lower and ex-tenant castes have been emulated by the same reason, as they have now acquired ownership over more than 100 acres of land. But we should not forget the fact that these proletarianised and bourgeoisiefied families are hardly five percent of the total number of families in the six villages.

The process of cultural transmission, that is, Sanskritization (Srinivas : 1966), has also only a limited role to play in levelling the vast economic and social divergencies that exist today in the village community. The sanskritizing castes adopt generally what the superior castes consider out-dated and obsolete and by the time the lower castes adopt the elements which the upper castes cherished, the latter socialize or legitimatize new bases of higher status and prestige (Lynch : 1968). Moreover, Sanskritization does not break-through the economic inequalities and provide incentives for structural upheavals.

The process of modernization has also been referred to as the mechanism for achievement of an egalitarian social order. As modernization results in a high level of structural differentiation, social mobilization in terms of decentralization of unified and centralized institutions and organizational networks. But modernization depends upon institutionalization of modern values and the adaptability of the society concerned at large. Institutionalization of values refers to the nature of existing stratification system, and capability for adaptability is analogous to cultural legitimization as referred by Parsons (1964). The nature of our stratification system is segmental and hierarchical, and therefore, the difficulty is not so much of changing the values, but of providing resources to backward families and groups to adopt and internalize the modern ethos and benefit from consequential beneficial effects. The privileged sections conserve the newer bases of status and power, such as education, office, lucrative jobs, innovations, outside contacts and styles of life etc. The result is that the non-privileged sections remain deprived of these new bases, and the unequal distribution of resources and power persists. Thus, the direction of the process of modernization denies ' distributive justice ', and allows concentration of resources in a few hands. What we need is controlled and directed modernization which can ensure maximum decentralization of resources and justice and equality to all sections of our society.

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Conclusion :

The Gandhian approach to stratification has a predilection for functional system of social relations. But at the same time Gandhi's aim was to achieve a classless and ultimately a stateless society. The theory of action which Gandhi has propounded, has not given, however, radical results towards that end. This is primarily because of the impediments which our stratification puts in this regard. The nature of the processes of change is such that it does not allow a break-through in the existing stratification solidarities. Gandhi was a practical man, he did whatever he preached. This was the reason that he could have mass mobilization in a charistimatic way. After Gandhi the gulf between the ideology and action has increased so much that we observe mainly verbalization and sloganism and not percepts of action and implementation.

There will persist a certain amount of inequalities in all types of stratification systems irrespective of their labels, such as capitalist, communist and Gandhian. Therefore, the processes of change which emerge out of forces and factors which we introduce must result in the maximum minimization of inequalities and increase of equality, distributive justice and decentralization of economic, social and political power. The nature of our stratification needs still radical structural changes to ensure the achievement of these lofty goals of a non-violent social order.

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A STUDY OF EDUCATIONAL CHOICE AND SOCIO-ECONOMIC BACKGROUND OF COLLEGE STUDENTS*

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A study of the factors bearing on students' educational choice has importance in present day context of increasing unemployment in certain sectors and inadequacy of qualified hands.

Introduction :

Generally it is observed that in any country the social and economic conditions have a large bearing on its educational system. The cost of higher education is higher than that of primary and secondary education. It is not easily possible for students of all social classes and economic groups to go in for higher education without any external assistance.

Recently increased facilities have become available to the students by way of scholarships and freeships from various endowments and government aid to B.C. and E.B.C. students, so there are more opportunities now for the poor students to get higher education while a few years back many bright students were not able to prosecute higher studies because of thier poor financial conditions.

It is also observed that there is a blind rush for some branches of education such as technical, engineering, medical etc. Why ? Incidence of unemployment on the other hand is the highest among Arts and Commerce graduates.

In the Gujarat State as a whole during 1967, there were 62,676 registered educated unemployed and 91,992 registered uneducated unemployed, while in 1968 there were 68,967 registered educated unemployed and 10,01,378 registered uneducated unemployed. There is an increase of about 11% among the educated unemployed during the period of 1967 to 1968[1].

* The present research was financed by U.G.C. during the year 1966-67.
1 Data by the courtesy of the Director of Employment, Gujarat State.

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Moreover the students are mostly coming from illiterate and semi-illiterate families. They are badly in need of proper educational and vocational guidance.

Purpose of the Study :

It was the aim of the present research to study the relations between educational choice and socio-economic background of the students.

In this investigation the author has tried to clarify the following points ;

1. The factors influencing the students' educational choice.
2. To study students' socio-economic background.
3. Is there any interdependence among the following associations ?
   (1) Income — Education
   (2) Income — Caste
   (3) Income — Occupation
   (4) Caste — Occupation
   (5) Caste — Education
   (6) Occupation — Education.

Sample :

The sample consisted of 1294 Pre-University students randomly selected from those admitted to the 27 Arts, Science, Commerce and Agriculture Colleges of Kaira District in 1966–67. This number represents 23.29% of the total population, i.e., 5575 admitted to the Pre-University classes of all these 27 colleges.

Method of Data Collection :

The instrument of data collection consisted of a questionnaire. The questionnaire comprised 27 multiple choice (fixed alternatively) questions and 3 open-end questions. In order to establish rapport, the purpose of the study was explained to groups of students whom the researcher met before the questionnaire was administered.

Analysis of Data :

The data have been tabulated separately facultywise, agewise by year of passing S.S.C., by marks obtained at the S.S.C., sexwise, religionwise, by choice of faculty, according to reason for joining faculty, according to what source of information was instrumental in faculty choice, by suitability of economic condition, according whether any thought was given at all before choosing a particular faculty, by source of income and financial support, according to future plans, and the reason for these, communitywise, by marital status, according to family type and family size, by educational level of guardian or father and of mother, by father's occupation, and according to the level of family income.

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Study of Bivariate Tables :

In order to study socio-economic background of college students of Kaira District, bivariate tables were prepared.

The available information about income, caste, occupation and education from the filled up questionnaires has been tabulated into bivariate tables. The expected frequencies have been calculated for each table by contingency tables. The original tables contain many entries where values were less than five. The contingency tables are formed by totalling appropriate combinations of rows columns.

Chi-Square has been calculated for each table, as Chi-Square itself does not constitute a very useful measure of association, the measure suggested by Karl Pearson which is known as " C " a person's co-efficient of contingency and another measure of association suggested by Tschupro[2] which is noted as "T" and have been calculated for each bivariate table. The value of " C " and " T " can be calculated as :

(1)

$$C = \sqrt{\frac{\chi^2}{N + \chi^2}}$$

Where Chi-Square is the usual calculated value from data and N is the total population.

(2)

$$T = \left\{ \frac{\chi^2}{N\sqrt{(p-1)(q-1)}} \right\}^{\frac{1}{2}}$$

Where Chi-Square and N are as above and p and q represent number of attributes rowwise and columnwise respectively.*

Interpretation and Conclusions :

1. The time-lag of 1-6 years between passing S.S.C. and entering college is lowest in science faculty and highest in arts faculty. The problem of waste of years can be studied in all faculties.
2. Wastage of years between passing S.S.C. and entering college by the students is the highest (57%) in the arts faculty and 45.44% in science faculty, is 47.50% in commerce faculty and 34.41 in agriculture faculty. This shows that more thorough investigation into the exact causes of this waste is needed before remedial measures could be suggested.

* The author is highly obliged for preparing contingency tables and for making available the services of the computer section at Physical Research Laboratory, Ahmedabad.

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3. Our sample shows that the absorption of brighter students is highest in science faculty while it is lowest in commerce faculty (during 1966*a*–67). This shows the relative importance students attach to these faculties.

4. More female students go in for Arts than for Science, Commerce or Agriculture. The proportion of female students in Kaira District in arts faculty is high.

5. 73% of students of arts faculty showed their willingness to join arts faculty while 70% of students of science showed interest in science faculty. 76.50% commerce students showed interest in commerce faculty, and 7.72% agriculture students showed interest in agriculture faculty. This shows a clear tendency among students to select what their interest is in.

6. A very low proportion of students took advantage of vocational guidance services. This may mean that there is no adequate provision for giving guidance to students or that there is some provision but students are not aware of it or they do not make use of it.

7. Nearly 40% reported unsuitable economic conditions. How far this is related to performance is an important point of enquiry which needs a more comprehensive study.

8. Interest, social service, and good salary prospects are the strongest motivating factors for future vocations.

9. There are more married students in arts and agriculture faculties. In science and commerce faculties the percentage of married are 4 and 3 respectively. This also indicates that early marraige is not prevalent in this area.

10. That 70% in Arts, 50% in Science, 74% in Commerce and 60. 58% in Agriculture come from divided families shows that joint family is vanishing not only in urban areas but also in rural areas.

11. Study has shown that illiteracy among mothers is greater than that among fathers.

12. A very large majority of students are still getting information regarding future plans of study from such unorganised and lay sources as their friends, parents and relatives.

13. The highest percentage of higher income group students (parent's income more than Rs. 500 p.m.) is in the commerce faculty (23.50 %), and are lowest in agriculture faculty (10%). The percentage of low income groups (i.e. below Rs. 200/– p.m.) is highest in science faculty (52.58%), 54% in Arts, 52.50% in Commerce and 57.21% in Agriculture. This indicates that majority of students have family income less that Rs. 200/– p.m.

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14. In agriculture faculty only 9% of the students wish to join actual agricultural work and the majority of the students (above 60%) have no real idea about their future career.
15. Only 17% of the students of agriculture said that they would prefer private farming as their career which is very low. Further investigation is needed on this problem.
16. Income and education of the guardians of the students indicates that low income goes with low education and high income goes with higher education. In other words, the education of a person is dependent on his income or vice versa.
17. The distribution of income and caste of the guardians indicates that there is no association between income and caste, because the Chi-Square is not significant.
18. The classification of income and occupation indicates that the association between income and occupation is significant because the Chi-Square is significant.
19. The classification of caste and occupation of the guardians leads us to conclude that occupation has been partially influenced by caste because the Chi-Square is significant.
20. Education does not depend much on caste, but there is some association between caste and education because the Chi-Square is not significant.
21. There is some positive relationship between occupation and education because the Chi-Square is significant.

Summary :

The purpose of the present research was to study what factors influence students' educational choice, in the light of their socio-economic background. The data was collected by questionnaire method from 1294 students which formed 23.29% of the total population of their type.

Many of the students choose their faculty for such extraneous reasons as :

1. Availability in the town or village
2. Relative cheapness of the course
3. Opportunity for easy and attractive employment
4. Light work
5. Pressure of parents or guardians
6. Low percentage at S.S.C.
7. Part-time study facilities.

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The tendency is that students securing high percentage of marks join sciecne faculty where standards are high. We also found that students have no clear-cut idea why they select a particular faculty. They are led by dominant social and cultural values. Moreover, it was also found that students do not know about the function of education and vocational guidance. In any case such services are not available close to them, or students are not aware of these provisions or they do not make use of these provisions.

Interest, social service, and good salary prospects are the strongest motivating factors for future vocations.

A large majority of the students of all faculties came from families with income below Rs. 200/- per month. The majority of students were from nuclear families rather than from joint families even in the predominantly rural area covered by this study.

Moreover, education has higher association with income than it has with occupation, its association or relation with caste, however is less. Thus association or relation with caste is less. The income of guardians seems to be the most important factor in the education of the child. It is also found that occupation is the next responsible factor, but there is little association between caste and education.

Among the guardians of the students the relation between income and caste and between income and occupation is equal but that between caste and occupation it is the highest.

On the one hand there is a rush for higher education and on the other there is increasing unemployment of the educated. This problem will demand immediate attention and action on the part of all concerned.

Suggestions for further Research :

1. Many students come from illiterate and semi-literate families. The value structure of their parents with regard to their education could be profitably studied.
2. Aptitude and achievement tests have to be developed for college students so that they can make meaningful educational choice with their help.
3. Economic conditions affect students' attitudes and performance and these can be profitably studied to detect their impact on students' attitudes towards education and on their performance.
4. The problem of waste of years in all the faculties can be studied in terms of time, money and labour.

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A STUDY OF THE DROPOUTS IN POST-GRADUATE EDUCATION

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[The present paper is a summary of the full length typed report which is available for reference at the Gujarat University Library. The study was supported by the Gujarat University.]

I INTRODUCTION

The Post-independence period has been a period of educational renaissance. The educational system in the country has grown in terms of the numbers being enrolled as well as in terms of variety of courses and institutions. This growth has its impact at all the stages of education, beginning from the pre-school to the doctoral. The demand for expansion and variety has been pressing and continuous.

Such situations are commonly observed in developing nations. It is also true that such nations, at a point, do feel the strains of expansion and are inclined to look back and take stock of the situation. It is necessary for a developing nation to ascertain whether maximum use is being made of its very limited financial resources.

In the field of education, such stock-taking has various dimensions which can be described as follows :

(*i*) Estimation of wastage and stagnation and diagnosis of their causes with a view to proposing suitable remedial measures

(*ii*) Evaluation of the quality of the human material turned out by the educational institutions

(*iii*) Development of education in relation to the nation's man power needs

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The first dimension has attracted many a research worker. Most of such studies in India concern themselves with the primary and / or secondary levels of education. A few of them deal with the college level (i.e. the undergraduate level) also. Only one published study[1] of wastage at the post-graduate level is known to the present investigators. This study, based on the data in the years 1953-58, concerns the Gujarat University. But it is limited only to the post-graduate departments conducted directly by the University. The present study is planned to be more extensive and detailed. Besides, the detailed record of the students registered for the post-graduate courses, kept at the Gujarat University, was a further incentive to undertake such a study.

Scope of the present work :

The object of the present work is to study the phenomenon of wastage and stagnation at the post-graduate level in the Gujarat University. The scope of the investigation has been limited to the data available from the records kept by the University office. The objectives kept in view are enumerated below :

1. To obtain subjectwise, yearwise and institutionwise estimates of—
   (*i*) passes and dropouts
   (*ii*) students who file their applications for the examination, once or more than once, but fail or remain absent
   (*iii*) students who keep the required terms but do not file their applications for the examination
   (*iv*) students who do not keep the required number of terms
2. To study analytically, subjectwise and yearwise—
   (*i*) the proportion of the various types of dropouts
   (*ii*) the time taken by the students to complete the course
   (*iii*) the number of trials taken by the students who failed or remained absent at the examination
   (*iv*) the number of terms kept by the students out of the required number
3. To obtain subjectwise and yearwise estimates of dropouts at different levels
4. To study sex differences with reference to—
   (*i*) The number of male and female students registered, passed and dropped out

1. M. C. Jaiswal, 'Wastage and Stagnation of the Post-graduate Students of Gujarat University Schools', *Vidya*, Vol. V., Nos. 1-2, March-October 1962, pp. 63-78

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(ii) the time taken by the male and female students to complete the course

(iii) the number of trials taken by the male and female students who failed or remained absent at the examination

5. To study analytically and subjectwise the classes obtained at the first degree examination by the students who registered

6. To study analytically and subjectwise the degree of appropriateness of the subjects chosen by the students for the master's degree courses in relation to the ones offered at the first degree examination

7. To study success in relation to the subjects studied and the performance at the first degree examination

8. To compare the performance of students taking part-time and full-time instruction

9. To compare the class obtained and the degree of appropriateness of the subjects offered at the first degree examination by the students taking part-time and full-time instruction

10. To study the effect of the reorganization of the post-graduate courses, since June 1966, on the dropouts

11. To study the subsequent performance of the students who obtain A.T.K.T. i.e. who are granted permission to keep terms for the higher level

Definition of terms :

The term "post-graduate" refers to the courses after graduation for the first degree leading to the master's degree.

Eventhough the study has been categorized as one in "wastage" and "stagnation", the terms have been purposely excluded from the title. Their use was found to be essential to indicate broadly the nature of work. However, the present investigators feel that the established connotations of the terms are not acceptable in the context of post-graduate education. It has been observed by most of the previous researchers, in the fields of secondary and university education, that the term "wastage" cannot be strictly applied beyond grade three, and that the higher you go in the educational ladder, the lesser becomes the applicability of the term. It seems to be applicable in case of a third or fourth grader, dropping out of school and lapsing into illiteracy. This can be looked upon as a waste of time, money and effort. But the same is not the case with a student who drops out at any of the later stages. Such withdrawals are, of course, premature, in relation to the objectives of a particular stage of education. But a student who fails to reach the final target in a stage, cannot be presumed to have gained

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nothing out of the school or college education. The very acquisition of permanent literacy itself qualifies the individual for self-education. Thus the time spent in a higher stage without successful completion of the course cannot strictly be said to have led to "wastage".

In view of this, the term "dropout" in place of the frequently used term "wastage" appears to be more suitable. It indicates a student, who does not successfully complete the course i.e. pass the examination, leading to the master's degree, but drops out before reaching the target due to failure or giving up the course for any reason. However, it is true that the levels at which students drop out are different in case of different individuals. The present study endeavours to estimate the dropouts at various levels.

The term "stagnation" is often used to indicate a student's failure to complete a course of study in a stipulated period. "Stagnation" is thus used synonymously with "detention" and / or "retardation". It, therefore, cannot be appropriately used in case of a post-graduate student whose success is delayed on account of indifference and / or lack of ability or some such cause. Unlike a school boy, this university student is likely to have acquired some training or job experience during the period of detention. Hence what is usually described as "stagnation" is studied in this investigation as "delayed success".

The institutions teaching the post-graduate courses are often referred to as two different types, "departments" and "centres" in this investigation.

"Departments" are institutions, housed on the University campus and run under the direct supervision of the University authorities, with the staff, who devotes full time to post-graduate teaching and research and who are full-time employees of the University. However, recognised post-graduate teachers from the affiliated colleges are often invited to help whenever there is extra workload of lectures or teaching of a subject which cannot be managed by the department staff.

"Centres" are post-graduate classes run at the premises of the affiliated colleges as per the condition laid down by the University. The staff working in these "centres" comprises college teachers recognised by the University for post-graduate teaching though this staff is mainly occupied in teaching the under-graduate classes. They are, however, paid extra for this post-graduate teaching by the University on the basis of lectures given by them.

Selection of the sample :

Most such studies are conducted by taking a batch of students entering a particular stage and then following it through. The same procedure is adopted here and it has been thought advisable to take three such batches so

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as to check the repetition or otherwise of the phenomenon observed in the first batch.

Period of study : The data for the study were collected during the academic year 1969-70 and the students selected were those registered for post-graduate studies in the academic years beginning with June, 1963, 1964 and 1965. These years were chosen in view of the following :

(*i*) Sufficient number of opportunities to take the master's degree examination had been available to them.

(*ii*) These were the batches which preceded the reorganization (described later) of post-graduate teaching and were, therefore, useful for a comparative study.

(*iii*) They were not far removed from the impact of current educational changes in the University.

Faculties : The study was extended to the students of six out of a total of eight faculties offering post-graduate courses during the years under study. The faculties included in the present study and those not included are listed in the description of the sample chosen.

Students : The usual practice is to select for study, a sample of the total population by employing suitable sampling procedures. But the availability of data regarding all the students registered tempted the investigators to study the entire populations during the three years and thus avoid the possibility of sampling errors getting into the study.

Besides, the intention to carry out the study subjectwise and institution-wise also necessitated the inclusion of the entire populations without which an adequate sample size for each group to be studied, would not have been available.

Sample for comparison :

From June 1966 onwards, the Gujarat University implemented the reorganization of post-graduate teaching. The main feature of this reorganization was the splitting up into two parts, the master's degree courses in most of the subjects. The student, in this new set up, is required to attain a certain achievement level at the part I examination so as to be eligible for admission to the part II courses. The intention was to study the effect of the new requirements on dropouts. Hence, some twentyone subjects, covering the faculties of Arts, Science and Commerce, having an appreciable number of students registered in June, 1966 were chosen for this comparative study. In this case also, the entire student populations, registered in the selected subjects, were included in the study.

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The facultywise and yearwise description of the population chosen for the study is given below :

Description of the Sample

Sr. No.	*Faculty*	*Year of registration* 1963 *N*	1964 *N*	1965 *N*	*Total* 63–65 *N*	*Yr. of reg.* 1966 *N*
1.	Arts including Education	1403	1637	1726	4766	2018
2.	Science including Maths. & Statistics	340	382	472	1194	669
3.	Commerce	281	491	478	1250	604
4.	Law	75	63	85	223	—
5.	Engineering	21	12	16	49	—
6.	Medicine (only Pharmacology)	12	12	17	41	—
7.	Agriculture	—	—	—	—	—
8.	Ayurved	—	—	—	—	—
	Total	2132	2597	2794	7523	3291

Collection of data :

From the year 1960 onwards the Gujarat University has been maintaining a systematic record of all the students registered for post-graduate studies, with a view to facilitating the office routine. The availability of these records has been the most valuable help in the present study. Without it, the study would have been less accurate and comparatively limited in extent.

The form developed for this record included the following details :

Registration no.; registration receipt no. and date; name; sex; eligibility certificate no.; degree; subjects (principal or subsidiary, if any); attendance, separately for four terms, specifying the no. of total lectures delivered, required, and attended; the year or years in which the application for the examination was filed; examination result; remark.

In addition to this, the University has tried to preserve, as far as possible, the files of the registration forms filled in by the students. These contained two items of value to the study, the subjects offered and the class obtained by the student at the first degree examination.

Based on the data, available from both these records, a special proforma, suited to the purpose of the study, was developed. The items of information regarding the students included mainly the registration number, name, sex, terms,

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examinations as well as subjects and class at the first degree. For students, registered in June, 1966, the information was recorded separately for parts I and II.

The data obtained was tabulated and studied in view of the various objectives of the study.

II. SUMMARY OF FINDINGS AND CONCLUSIONS

Survey studies are oriented toward determining the present status of a given phenomenon and are certainly, of relatively limited scientific sophistication. However, such studies do provide an indication of trends and hypothesis as to the antecedents of the status noted.

This section summarises the major findings and the conclusions drawn therefrom. Some issues which might interest future research workers are also listed.

The Major Findings

The findings are grouped into different categories.

Registration :

1. There is an increase in the number of institutions and students from year to year.

2. The number of students per institution is found to be approximately 22, 25 and 26 in the years 1963, 1964 and 1965 respectively.

3. The largest number is registered in the Languages and Social Sciences groups. This is about 60% of the total registration. Among the remaining subject-groups, Professions contribute about 23%, Natural Sciences 11% and Mathematics 6%.

4. The subjects in which relatively higher percentage of students, within the subject-group, register, are Gujarati principal, Entire Economics and History, Economics, Chemistry, Mathematics and Commerce.

Estimates of passes :

1. The passes in the University as a whole are estimated to be about 41-42 per cent.

2. The Natural Sciences group surpasses the other four groups in the estimates of passes which are 76, 87 and 81% in the years 1963, 1964 and 1965 respectively. The percentage of passes in the other groups are mostly in the thirtees and occasionally in the forties and twenties.

3. The subjects in which an appreciably higher percentage of students, within the subject-group, passes, are Sanskrit principal, Entire Sociology, and Statistics.

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4. The subjects in which an appreciably lower percentage of students, within the subject group, passes, are English principal, History-Economics, Mathematics and Law.

5. The lowest percentage of passes (5, 3 and 5) is observed in Law for each of the three years.

Proportionate contributions to dropouts :

1. The Languages and the Social Sciences groups, which contribute about 60% to registration but 68% to dropouts, appear to be responsible for inflating the dropout figures in the University.

2. The Natural Sciences with 11, 10 and 11% contributions to registration but only 4, 2 and 3% contributions to dropouts help to raise the average percentage of passes in the University.

3. The Mathematics and the Professions groups maintain a fair balance between their contributions to registration and dropouts.

Types of dropouts :

1. In the University as a whole, the percentage of those who fail or remain absent (F.-Ab.) at the examination is equal to or slightly higher than the percentage of those who fail to keep the required number of terms (T.N.G.).

2. Quite a few exceptions to the above are observed in the Social Sciences and Professions.

3. In the University as a whole, the percentage of students who drop out after keeping all the four terms but without registering for examination even once (T.G.) is appreciably lower (12%) than the percentage in the F.-Ab. and T.N.G. groups.

4. Subjects other than Commerce in the Professions group are marked out as deviants, for in most cases the percentage in the T.G. group is higher than that in the F.-Ab. and the T.N.G. groups.

Dropouts at different levels :

1. About 34–36% of the students registered never cared to take the examination.

2. The percentage dropping out after keeping no term or one term is generally higher than that dropping out after keeping two or three terms.

3. The percentage dropping out after keeping three terms is appreciably low in comparison to that dropping out at each of the earlier levels.

4. In the University as a whole, about 7–8% percent, drop out after keeping no term and about the same percentage does so after keeping one term. The percentages of those who drop out after keeping two, three or four terms are respectively 6, 2 and 12 in all the three batches.

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5. Among the failures, the percentage dropping out after one trial only is generally higher than the one dropping out after 2 or more trials. This happens almost invariably in each case in the Social Sciences and the Professions group, whereas subjects in the Languages group do not show a consistent tendency in the matter.

6. No generalization regarding the percentage taking 2 or more trials can be made.

Delay in success :

1. In the University as a whole, 55–56 per cent of those who pass manage to do so within the stipulated period i.e. two years.

2. A slightly higher percentage passes within the stipulated period in the Natural Sciences group.

3. Among the delay categories i.e. those taking 3, 4 or 5+ years to pass, no really consistent trends can be observed except that generally the percentage passing in three years is appreciably higher and decreases in the subsequent categories. About 8–10% of those who pass, take 5 or more years.

Sex difference : Registration :

1. About 15–16% of the total students registered in the University are females.

2. Sociology-Psychology has almost been rendered feminine as 67–90% of the students are females. The percentage of females registered in Entire Sociology, Entire Psychology and Entire Philosophy range between 35 and 52; they are also equally high, occassionally, in Sanskrit principal, Economics-Sociology and History-Sociology.

3. The subjects in the Natural Sciences group are largely monopolized by the males. In the Professions group, comparatively more females go to the Education and the Pharmacology courses and the percentage attending the Commerce courses is as low as one or two.

4. The percentage of females registered in the Languages is the highest whereas it is the lowest in the Mathematics group.

5. Taking the percentages in the year 1965 as a representative illustration, it is observed that 44% of the total female students registered in the University, study Languages, 42% Social Sciences and Philosophy, 7% Natural Sicences, 1% Mathematics and 6% Professions.

Sex difference : Passes :

1. The percentage of passes among the females in Languages and Social Sciences and Philosophy is higher by 8 to 21 points than that among the males.

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In the remaining three subject groups, the performance of the male students is only slightly superior.

2. The female students maintain superior or fairly comparable results in all the subjects except in Law, where out of the sixteen females, registered during the three years under study, not a single one has passed.

Sex difference : Dropouts :

1. The percentages of male and female students in the F.-Ab. and the T.N.G. groups in the University are fairly comparable.

2. In a very large majority of cases, the percentage of females in the T.G. group is appreciably lower.

3. In the University as a whole, the percentage giving up studies after one trial in the F.-Ab. group is higher in the case of both sexes.

4. A decrease in the percentage as the number of examination trials increase is more marked and consistent among the female students.

Sex difference : Delay in success :

1. The percentage of passes within the stipulated period of two years, is appreciably and consistently higher among the female students in all the subject-groups, including the Natural Sciences.

2. The percentage of females, passing in 4 or 5 + years is mostly lower than that of the male students.

First degree performance :

1. The 'stuff' admitted appears to be quite up to the mark in case of most subjects in the Natural Sciences, Mathematics and Professions (except Commerce) groups.

2. Several subjects in the Languages and the Social Sciences and Philosophy groups appear to be partially or largely handicapped in the kind of 'stuff' to be handled. Sanskrit principal appears to have no difficulties and Entire Sociology, Entire Psychology and Economics-Sociology have quite a tolerable 'stuff'. Gujarati principal, Hindi principal, Entire Economics, Entire Politics, Sociology-Psychology, and History-Economics, though crowded by the pass classes, are in a happy position as regards the degree of suitability of the subjects offered at the bachelor's degree examination.

3. The general quality of the 'stuff' admitted in a subject, compared with the percentage of passes in that subject, does not help to develop a really cogent argument. For example, the percentage of passes in the Mathematics and Professions groups is in no way comparable to the one in the Natural Sciences group.

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4. The hypothesis—that the higher the class obtained at the first degree, the better would be the percentage of passes at the master's degree level, provided that the degree of suitability of the subjects offered remains the same is retained in case of 21 out of the 29 subjects studied. The variants are Hindi principal, Education, Entire Sociology, Statistics, Organic Chemistry, Inorganic Chemisry, Engineering and Law.

5. The premise—that a second class or a pass class in a subject category of a higher degree of suitability, would be expected to fare better than his counterpart in a subject category of a lower degree of suitability–is rejected in case of eight out of the fifteen subjects to which it was relevant. These are—

(*i*) English, Gujarati and Hindi as principal subjects
(*ii*) History, Sociology and Psychology as entire subjects
(*iii*) Economics–Sociology and Mathematics
Four of these deviations could, however, be explained.

6. The assumption–that irrespective of the degree of suitability of the subjects chosen, a first class, in any case, is superior to a second class, who in turn is superior to a pass class at the first degree level–is substantiated by results in thirteen out of fifteen subjects.

Departments and centres : 'Stuff' admitted :

1. The percentage of first and second classes admitted is appreciably higher in the departments.

2. In the matter of suitability of the subject, the two compare fairly well, except in case of Entire English and English principal, where the percentage having a low degree of suitability, registered at the centres is really high–70 and 45 respectively. Similar is the case, though to a lesser degree, in Gujarati, Entire Psychology, Mathematics and Hindi.

Departments and centres : Number registered :

1. The number registered for each subject at the department compares fairly well with the average of the one registered at the centres; however, classes in certain subjects at some centres are found to be really crowded.

2. No relationship between the number registered in a class and the percentage of passes was observed.

Departments and centres : Passes :

1. In eleven out of the twentynine cases studied, the percentage of passes at the departments is more than double the one at the centres; it is appreciably higher at the departments in fourteen cases.

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2. The four cases in which a relatively higher percentage of passes is observed at the centres are located in Organic Chemistry (1963-64), Statistics (1963) and Mathematics (1964).

3. The difference between the percentage passing at the department and at the centres is not particularly marked in case of Gujarati and Physics.

4. On the whole, the pass percentages are 66-38 (1963), 64-34 (1964) and 58-29 (1965) for the departments and the centres respectively.

5. In the matter of the actual number passed per year-subject-institution, the departments lead in 27 out of 29 cases. The two exceptions are in Entire Psychology (1963 and 1965).

Departments and centres : Dropouts :

1. On the whole, the percentage of students, in the T.G. group in the departments is only 2 (1963 and 65) and 1 (1964) compared to 12 (1963-64) and 13 (1965) in the centres.

2. The percentages of students in the F.-Ab. group, on the whole, in the departments and the centres are 13-31 (1963), 19-30 (1964) and 24-38 (1965) respectively.

3. Unlike the T.G. and the F.-Ab. groups, the T.N.G. groups in the departments and the centres are fairly comparable in spite of a remarkably higher percentage of passes in the departments.

Outcomes of reorganization :

1. The percentage of passes in the 1966 batch, which took the part I and II examinations separately, shows a decrease, in most subjects, as compared to percentage passing within three years, in those subjects, during the earlier years.

2. At the end of part I, 58% of the students registered drop out. Thus, in the reorganized set-up about 35% more students drop out, during or after the first academic year.

3. In the new set-up, about 2% more students drop out at the end of the first term.

4. Compared to part I results, in part II the T.G. (2%) and the T.N.G. (1%) groups have been very small.

5. Among students who obtain A.T.K.T., only 15% pass at the part II examination, whereas the percentage in the F.-Ab. group is 62 and that in the T.N.G. group 3. Out of the remaining students, 5% are found in the T.G. group and 15% had not yet kept terms for part II.

Conclusions and Recommendations :

The findings, linked up as a whole, certainly make a sad story of post-graduate teaching in the University. It poses a problem, gigantic in size and

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complex in nature. There is so much to be done about it that one may be tempted to give up in despair. However, a beginning could always be made.

The present study does not and cannot claim to have analysed the situation completely. Its scope is limited by the fact that it is just a status survey, restricted only to the data available from the records kept at the University Office. Yet, the interpretation of the findings does lead to conclusions which may be taken up as hypotheses for further verification.

Plea for student involvement :

The problem of dropouts would be much less acute if the target attained by the Natural Sciences are reached by other subjects also. Therefore, the simplest measure to imitate the practices of the Natural Sciences.

The findings, in the matter of the 'stuff' admitted, tend to support the popular belief that more able students undertake the study of Natural Sciences or that able students get preference in admission to the science courses. But the 'stuff' admitted is found to be upto the mark in the Mathematics and the Professions (except Commerce) groups also. However, the percentage of passes in these subjects does not compare favourably with that in the Natural Sciences. Besides, Mathematics and Statistics are subjects, usually offered by students, seeking the M.Sc. rather than the M.A. degree.

Under the circumstances, it may be guessed that better results in the Natural Sciences are due to the practical work, which requires the students to study regularly and seriously throughout the two years. This inference is further supported by the fact that only one per cent of the students in the Natural Sciences does not appear at the University examination, although they keep all the four terms, as against 12% in the University as a whole. In most subjects, class attendance, which can be thoroughly passive on the part of the learner, is the sole requirement. The student does not have to be involved in the learning process. Consequently, he postpones the study to the examination season and finally feels diffident and gives up in despair or fails.

If this guess is valid, the need for student participation and involvement in the learning process throughout the two years, cannot be overemphasised. Methods of teaching geared to exacting day to day work from students through assignments—both oral and written—might help a great deal in bringing down the percentage of dropouts.

Need for screening :

The findings in the present study do not permit one to believe that student involvement is the only measure required. No method of teaching, however efficient, can help the student, without reference to his scholastic ability and

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background as well as his motivation and the realities of life which surround him. The admissions have to be selective. The criteria for such a selection, as per the findings in the study, are discussed below.

Scholastic ability and background : The class obtained at the bachelor's degree is the only available evidence to judge a student's scholastic ability. Accordingly, a group of second classes is found to fare better than that of the pass classes in this study. The superiority of the first classes over the second classes may just be inferred, though in view of the very small numbers of first classes, such a study has not been made.

The subject offered by a student for his bachelor's degree could be accepted as the most conveniently available criterion for judging his background. But the findings do not quite support the assumption that familiarity with the subject at the bachelor's level is really helpful. Irregularities in case of eight out of fifteen subjects was observed. However, most of these could be explained as under :

In case of the three languages, English, Gujarati and Hindi, it is possible that they had acquired proficiency and developed interest in the language elsewhere. Most of the students who apparently had poor background in Mathematics, had offered at the bachelor's degree, allied subjects, such as Statistics and Physics. As regards Entire Sociology and Economics–Sociology the previous background in Sociology, probably does not seem to matter.

It was, therefore, concluded that except (*a*) when a student has a background in the subject, through sources other than the first degree subjects or (*b*) when such a background is not of primary importance, it is wiser to admit, students who have offered subjects of a higher degree of suitability at the first degree, while selecting from among students who have obtained the same class.

Motivation and realities : In spite of good 'stuff' and programmes, the dropouts in the Natural Sciences range between 13 and 24%. First classes in these and other subjects also drop out. The percentage of passes among the second classes is not necessarily high. About 34–36% never cared to take the examination. And among these, about 14–16% drop out after keeping no term or one term, probably, before they have time to realize their own or teachers' inability. Besides, in case of all, circumstances could not have suddenly changed so as to compel them to give up their studies.

The root of the trouble seems to be a lack of seriousness on the part of the student. It may be that he really did not need the degree, or that he found it a difficult task in view of his abilities, industry, or other socio-economic liabilities.

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Guidance oriented procedures for admission are, therefore, recommended in place of selections only on the basis of class and subjects at the bachelor's degree or in place of open admissions to all and sundry. Such procedure would help the student to make a plausible educational plan.

Criteria for admission :

The following simplified procedure for screening is recommended:

Step 1 : All the applicants be arranged in order of the class obtained at the Bachelor's degree examination, from higher to lower.

Step 2 : Within each class, they be rearranged as per the degree of suitability of the subjects, studied at the Bachelor's degree examination, beginning from 'high' degree of suitability.

Step 3 : Admissions be granted in the serial order after checking the strength of a student's motivation, the feasibility of his educational plans as well as his proficiency in the subject.

The third step involves decision on the basis of guidance oriented interviews. Such a procedure may not be quite free from bias or malpractices, as it gives a free hand to those who decide admissions and is likely to lead to serious complaints. Much, however, depends on the integrity of those in charge of admissions. In order that the reliability and the validity of the decisions may not be doubted, it would be worthwile organizing a guidance oriented unit at the University, which might decide all admissions.

This procedure, however, goes against the educationally sound principle of associating teachers with the procedure of admissions to students whom they have to teach. They can, with experience, select deserving students for admission and given some training in granting admissions through guidance oriented interviews, they can make admissions with integrity. It is therefore suggested that those in charge of admissions be given a training in interviewing candidates so that the half-hearted and the undeserving can be weeded out from the very beginning and be saved from spending their time, money and energy fruitlessly.

Restricting the numbers by screening need not be misconstrued as violation of the principle of democracy in the form of open admission to all, as screening does safeguard democracy in the sense of giving equal opportunities to all those that deserve admission on the criteria laid down for admissions. The saving of time, money and energy of a section of the nation which does not deserve, does mean democracy.

It is not recommended that admissions be restricted to a certain number, uniformly for all the subjects. The number in the subject would

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depend on the number of students passing the Bachelor's degree examination with a particular subject as well as the importance of the Master's degree in a subject in the employment market.

Outcomes of reorganization :

The reorganization of the courses in two parts helps to quicken the process of dropping out. This is no small a gain. The value of such a situation, in terms of time, money and effort saved as well as of frustrations avoided, cannot be exaggerated. Having to welcome the dropouts, is certainly an ironical situation. But it only amounts to choosing the lesser evil. If after all, some students admitted are to drop out, it is better that they drop out at the earliest.

A high percentage of failures among those who obtain A.T.K.T. indicates a need for the reconsideration of the system on the basis of systematic investigation. Under the existing rules, these students are required to score higher at the part II examination, to make up the deficiency in part I. This is perhaps quite difficult for those who are very ordinary or even just average, and, therefore, the A.T.K.T. does not help them.

A decrease in the percentage of passes observed need not be attributed to the new set-up, as the rate of registration has also increased which probably means a larger proportion of half-hearted students among the registered ones. Besides, the set up is new and the students and teachers should have enough time to get accustomed to it. Time alone can decide to what extent the new set up is effective in raising the percentage of passes and in decreasing the rate of dropouts.

Improvement at centres :

Compared to the percentage of passes at the departments the one at the centres is appreciably low. The percetages in the F.-Ab. and the T.G. groups are rather high. It appears that, with the week-end classes at the centres, students probably find it convenient to keep the required number of terms in spite of reluctance to study or adverse socio-economic circumstances.

In addition to the general recommendations made for both the departments and the centres, some special measures will have to be adopted for raising the standards at the centres.

Adopting the principle of screening : Looking to the percentage of pass classes admitted at present, the admissions at the centres need rigorous screening.

Increasing the number of working days : Spreading out teaching, over at least four days a week, which may include the week-end, keeps

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the student involved throughout the academic year. Such involvement encourages him to put in more effort, which leads him ultimately to success. This will also eliminate the easy-going and the half-hearted ones. Moreover the teacher can find more time to work with his students. The intensive instruction results in greater confidence among the students, which in turn results in lowering the number of dropouts owing to sheer despair.

It may be noted that suitable steps are being taken in the direction by the University recently. But they need to be strengthened. Increase in the number of working days, without an appreciable increase in the number of lectures per paper or in the number of minimum lectures to be paid for, is not the solution.

Appointing a few full-time teachers : It is through the teachers that the student identifies himself with the institution. The centres are staffed by part-time teachers who have neither the time nor the need to respond to students' demand in this respect. It is true that a teacher seeks communion with his students, and wants to have the satisfaction of having done something for them and win their love and admiration. These are factors which contribute to job satisfaction among teachers.

The part-time post-graduate teacher gets it from his undergraduate students who occupy him most of the time and does not much care for it from his post-graduate work. It is, therefore, necessary that some teachers be left solely or mainly to work with the post-graduate students so that a desired rapport between them can be established. Such an arrangement is likely to result into better effort on the part of both. It is, therefore, recommended that full-time services of one or two properly qualified teachers be insisted on at the centres. This will raise the per capita expenditure at the centres, but the additional expenditure has to be found somehow if the national waste involved in large number of dropouts is to be eliminated.

Enriching the libraries : The library requirements for recognising an institution as a post-graduate centre need be made stricter. It would be really interesting to conduct a survey of these libraries. Most of them are reported to be poorly equipped.

Recognising the post-graduate teachers : The requirements for recognising teachers for post-graduate work need to be raised much higher than what they are at present. Some evidence for ability to think originally and organize, in the form of research studies or other publications of a higher level, should be expected of a teacher and not a mere master's degree and a few years of teaching the undergraduate classes.

Thus the need for screening not only the students but also the teachers as well as the institutions appears to be imperative. It is recommended

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that the minimum qualifications for the recognition of post-graduate teachers be raised and the existing teachers be re-recognised in the light of new requirements. The number of institutions, teachers and students needs drastic revision and reduction.

Miscellaneous observations :

Improved methods of teaching might help to lessen the percentage of delayed success.

A higher percentage of passes among the females, in general, may be attributed to the fact that a large majority of them probably come from the socially and economically advantaged class. The females are also likely to be more persevering and more sensitive to the feeling of social shame which a dropout has to face.

Compared to the males, the females are found to be rather reluctant in taking trials at the examination. This may be owing to the desire to avoid social shame which certainly increases by repeated failures. If something could be done to encourage the females, to face this, their percentage of passes might yet go up.

Problems for Study

1. The reasons why those who have obtained a first class at the Bachelor's degree drop out
2. The reasons why students drop out at different levels
3. The reasons why students who obtain A.T.K.T. fail
4. A survey of post-graduate libraries at the centres
5. Reasons why the success in case of some is delayed and what they do during the extra year or years
6. A comparative sample survey of the socio-economic background of the male and female students
7. The reasons why the females are reluctant to take trials at the examination
8. An estimate of the percentage passing till the April 1971 examination of the 1966 batch
9. A survey of the reactions of post-graduate teachers to various findings of the present study
10. A critical survey of admission criteria at different institutions

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"MORPHOLOGICAL STUDIES IN JASMINUM OFFICINALE LINN."

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Introduction :

The family Oleaceae is characterised by the presence of ranunculaceous stomata, unicellular, simple uniseriate, peltate glandular trichomes and sclereids (Solereder, 1908; Metcalfe and Chalk, 1950). The information given by them concerns the vegetative organs only. As far as the author is aware no report exists on the structure and ontogeny of stomata, trichomes and sclereids on the floral organs. The present paper deals with the distribution, structure and development of these structures on the different organs of the flower of *Jasminum officinale* Linn.

Materials and Methods :

The material of *Jasminum officinale* was collected from local gardens of the University campus. The flower buds were fixed in FAA and the usual methods of dehydration, infiltration and embedding were followed. Sections were cut at the thickness of 8 microns and stained with safranin and fast-green. Epidermal peels of sepals and petals stained with Delafield's haematoxylin mounted in glycerine were observed. For sclereids temporary whole mounts cleared in warm 2.5%NaOH stained with 1% aqueous safranin were also observed.

Observations

Stomata :

In the flowers of *Jasminum officinale* the stomata have been observed on the peduncle, pedicel, sepals, petals, ovary wall and integuments. The sepals and petals are hypostomatic. The epidermal cells are either polygonal isodiametric or elongated in various directions. The surface of the cuticle shows parallel corrugated striations. The meristemoids occur at random between the mature stomata. The meristemoid is either polygonal or trapezoidal, becomes distinguishable by its prominent nucleus and dense staining properties

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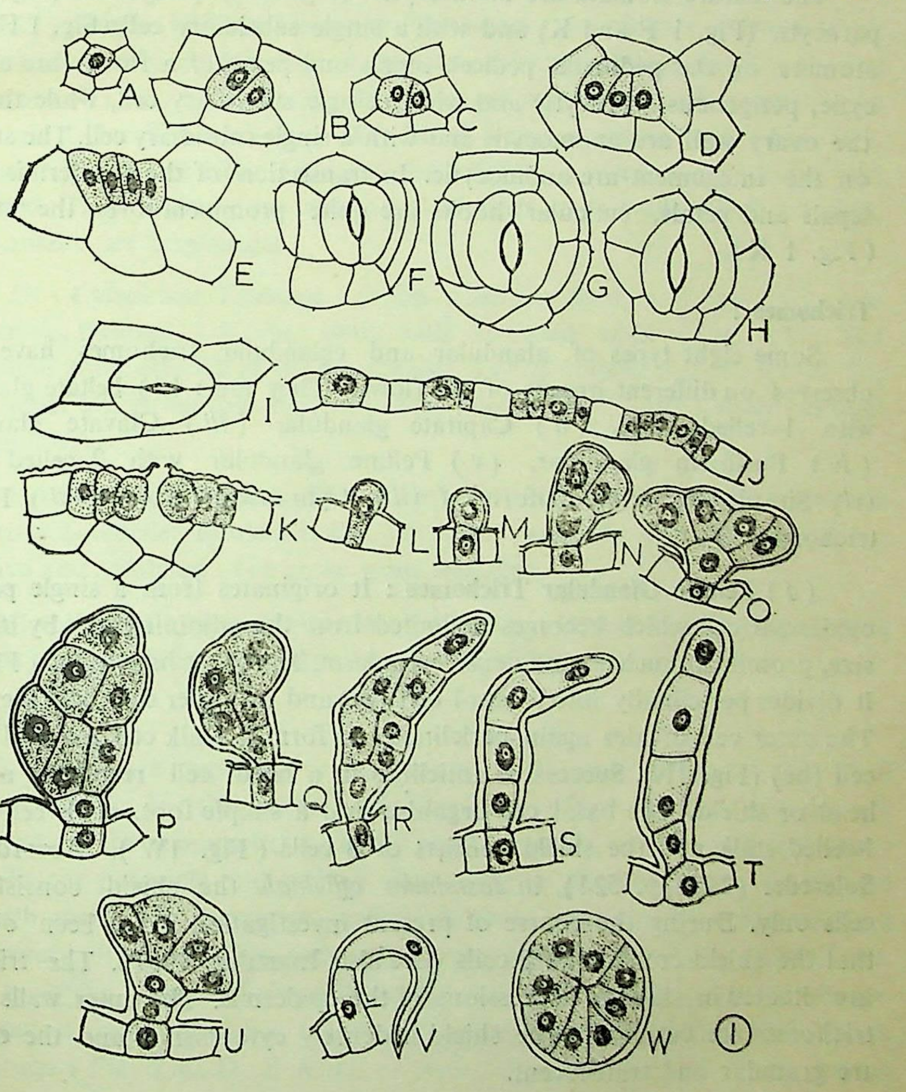
(Fig. 1A). The meristemoid directly becomes a guard mother cell and divides vertically into two equal guard cells without cutting off any subsidiary cells (Fig. 1B) or into two unequal cells (Fig. 1C). In the former case it develops into an anomocytic (ranunculaceous) stomata, while in the latter, the larger cell organises into a subsidiary cell and smaller one divides again to give rise to two unequal cells (Fig. 1 D). Of the three cells in a row, the central is smallest and becomes the guard mother cell. It divides vertically into two



guard cells which develop an intervening pore (Fig. 1 E, F, J and K). The mature stomata thus becomes paracytic (rubiaceous) (Fig. 1 F and K). In paracytic stomata, sometimes the subsidiary cells divide or the adjacent epidermal cells assume the form of subsidiary cells as a result of which the number of flanking subsidiary cells increase. Occasionally, of the two unequal

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cells (Fig. 1 C), the large one organises into the subsidiary cell while the smaller one becomes the guard mother cell. It divides vertically into two equal guard cells and develops an intervening pore (Fig. 1 H). Thus, the stomata has a single subsidiary cell. Sometimes in anomocytic stomata the adjacent epidermal cells divide and assume the form of subsidiary cells. The stomata, thus, becomes perigenous (Fig. 1 G).

The mature stomata are anomocytic (Fig. 1 I), perigenous (Fig. 1 G), paracytic (Fig. 1 F and K) and with a single subsidiary cell (Fig. 1 H). The stomata on the peduncle, pedicel, sepals and petals of a flower are anomocytic, perigenous, paracytic and with a single subsidiary cell, while those on the ovary wall are anomocytic and with a single subsidiary cell. The stomata on the integument are anomocytic. In transection of the epidermis of the sepals and petals, cuticular hooks are quite prominent over the stomata (Fig. 1 K).

Trichomes :

Some eight types of glandular and eglandular trichomes have been observed on different organs of the flower. They are : (*i*) Peltate glandular with 1-celled stalk, (*ii*) Capitate glandular (*iii*) Clavate glandular, (*iv*) Fusiform glandular, (*v*) Peltate glandular with 2-celled stalk, (*vi*) Simple uniseriate filiform, (*vii*) Cylindrical and (*viii*) Hooked trichomes.

(*I*) **Peltate Glandular Trichomes :** It originates from a single papillate epidermal cell which becomes delimited from the adjoining cells by its larger size, prominent nucleus and dense cytoplasm. This is the hair initial (Fig. 1L). It divides periclinally into a basal cell (bc) and an outer cell (oc) (Fig. 1M). The outer cell divides again periclinally to form a stalk cell (sc) and a head cell (hc) (Fig. 1N). Successive anticlines in a head cell result in a peltate head or shield. The basal cell organise into a simple foot. stalk cell into a l-celled stalk and the shield consists of 8 cells (Fig. 1W). According to Solereder (1908, p. 524), in *Jasminum officinale* the shield consists of 4 cells only. During the course of present investigation it has been observed that the shield consists of 8 cells (see also Inamdar, 1967). The trichomes are situated in shallow depressions of the epidermis. The outer walls of the trichomes are cutinised. The shield is densely cytoplasmic and the contents are granular and translucent.

Sometimes, in peltate glandular trichomes the stalk cell divides periclinally so that the stalk becomes 2-celled (Fig. 1U).

(*II*) **Capitate, Clavate And Fusiform Glandular Trichomes :** The sequence of development of these trichomes is similar to the peltate glandular

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ones except that the divisions in the head cell are not strictly anticlinal. They may be anticlinal, periclinal, oblique or irregular (see Inamdar, 1967). All three types of trichomes are situated in shallow pits of the epidermis, are differentiated into a simple foot, an unicellular stalk and a multicellular head. In the form they differ in their shapes only. They may be capitate (Fig. 1P), club-shaped (Fig. 1 Q) or fusiform (Fig. 1R). The outer walls of the trichomes are cutinised. The contents are translucent and granular.

(*III*) **Simple Filiform Uniseriate Trichomes :** It initiates from a single papillose hair initial (Fig. 1 L). It divides periclinally into a basal cell and an outer cell (Fig. 1M). Successive periclines in an outer cell results in an uniseriate 2–4–celled trichome. The basal forms a simple foot (Fig. 1S). The lateral walls are either straight or slightly convex or concave and cutinised. The trichomes are constricted at their cross walls which are thin. The contents are translucent.

(*IV*) **Cylindrical Trichome :** It has a simple foot and an uniseriate cylindrical, filiform 2–4–celled body with rounded apex (Fig. 1T), The trichomes is constricted at the cross walls, slightly nodulose at the joints. The cross walls are either thin or thick. The lateral walls are mostly straight and cutinised.

(*V*) **Hooked Trichome :** It is differentiated into a simple foot and an uniseriate 2–4–celled hooked body. The outer walls are straight, convex or concave and cutinised. The cross walls are thin.

All the eight types of trichomes are of common occurrence on peduncle, pedicel and sepals and are rare on the other organs of the flower.

Sclereids :

Sclereids are reported to be present in various organs of the plant (Esau, 1962). In the flowers of *Jasminum officinale* the sclereids are observed on the peduncle, pedicel, sepals, petals, anther wall and ovary wall. In the peduncle and pedicel they occur in the epidermis, cortex and the pith region. In the sepals and petals they occur in the epidermis and the mesophyll tissue. They occur in diffuse pattern and vary in their shapes. They have the shapes of the cells where they occur. They may be elongated, may or may not show tendency towards forking (Fig. 2 H & I) or polygonal (Fig. 2 C, D, E & J) or oval (Fig. 2 F & G). They have a thick stratified wall narrow to large lumen and narrow pit canals. The pit canals are mostly simple, rarely ramiform (Fig. 2 F), having straight or oblique disposition. In the mesophyll, they occur in small groups, while in the cortex and the pith they occur in large groups forming distinct strands (Fig. 2 J), rarely solitary (Fig. 2 G & H). In some cases bright shining

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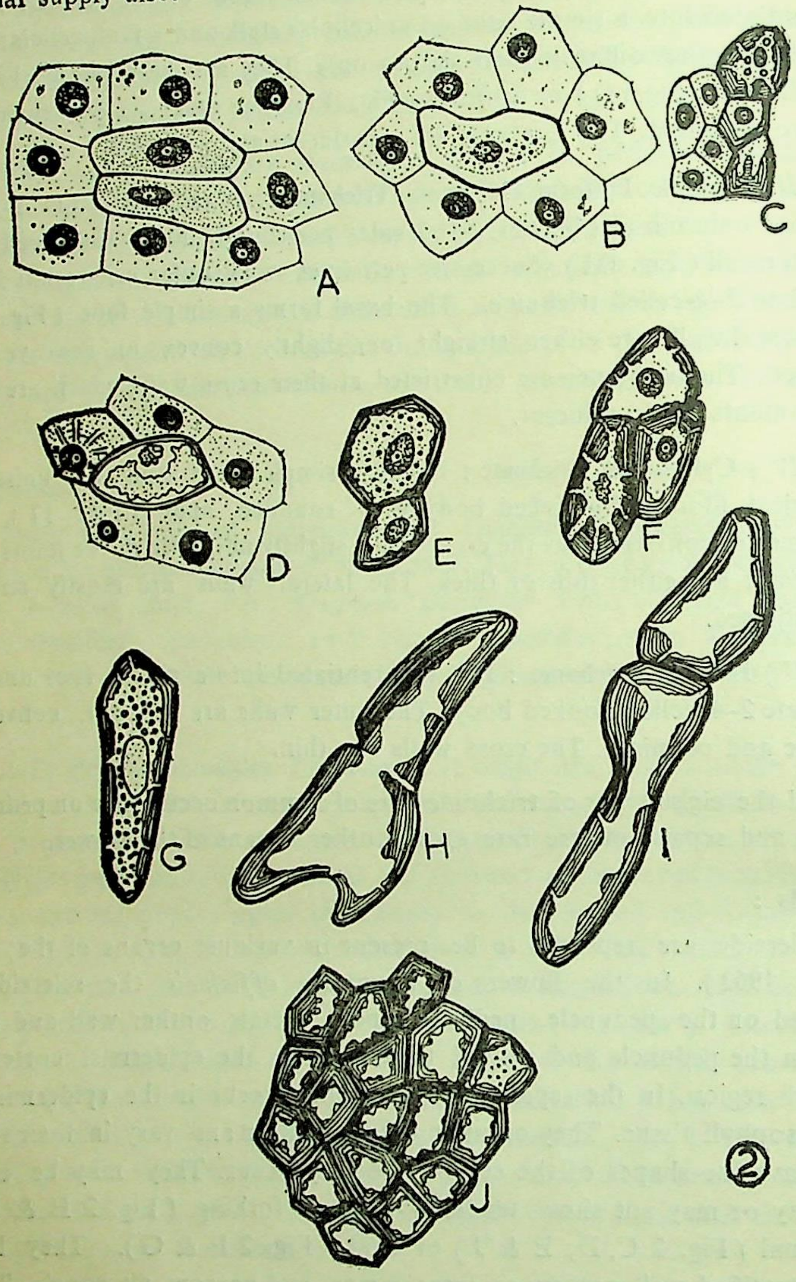
oval body and small granules of unknown nature are observed in the lumen of the sclereid (Fig. 2 G). They have been observed associated with the vascular supply also.



During ontogeny some of the epidermal cells or parenchyma of the mesophyll, cortex or pith differentiate as sclereid initials. They occur either solitary (Fig. 2 B) or in groups of 2-many (Fig. 2 A, C & D). They have a prominent nucleus, dense cytoplasm and rather thick walls. Sclereid initials

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which become sclerosed are stained light red with safranin-fast green combination. As development proceeds the cells show sclerosis, the cytoplasm contracts or appear in strands, vacuolation takes place and the nucleus show sign of degeneration (Fig. 2 B, C & D). The secondary walls show stratifications indicative of gradual centripetal deposition of cell wall material. Ultimately the nucleus degenerates and the cytoplasm disappears, sometimes the nualeus and the cytoplasm persists for a long time in the lumen (Fig. 2 E & F). The secondary walls show straight or oblique pit canals spread over without any uniformity (Fig. 2 F, G, H & I).

Discussion and Conclusion

The distribution, structure and ontogeny of floral stomata, trichomes and sclereids of *Jasminum officinale* are described here. According to Solereder (1908) and Metcalfe & Chalk (1950) in the family Oleaceae the stomata are renunculaceous (anomocytic), trichomes are of three types, viz., unicellular, simple uniseriate and peltate glandular.

Inamdar (1967, 1968) reported anomocytic, perigenous, paracytic stomata and stomata with a single subsidiary cell in the leaves of sōme members of Oleaceae. All the four types of stomata occur on the floral organs. All the types occur on the peduncle, pedicel, sepals and petals. On the ovary wall anomocytic and stomata with a single subsidiary cell are observed. The stomata on the integument are anomocytic. The ontogeny of the paracytic stomata and stomata with a single subsidiary cell conforms to the mesogenous type of Pant (1965). The development of anomocytic stomata is perigenous.

Inamdar (1967) described six types of trichomes on the vegetative organs of *Jasminum officinale*. During the course of present investigation the auth–ors have observed some eight types of glandular and eglandular trichomes on the floral organs. Peltate glandular trichomes with 2–celled stalk, cylindrical and hooked trichomes are new. The sequence of their development conforms to the type described by the senior author for vegetative trichomes of some Oleaceae.

Rao (1951) reported foliar sclereids in several species of Oleaceae. According to him the sclereids are terminal or diffuse. The floral sclereids in the Oleaceae are reported here for the first time. They exhibit diffuse pattern of their distribution. The floral sclereids are transformed epidermal cells or parenchyma cells of the mesophyll, cortex or pith. They are polymorphic,

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Explanation of Text Figures
Jasminum Officinale Linn.

Fig. 1 (A–W X 440)

A. Stomatal meristemoid
B. Meristemoid after division forming two primary guard cells
C. ,, ,, ,, ,, ,, unequal rectangular cells
D. Linear triad
E. Linear tetrad
F. Paracytic stomata
G. Perigenous stomata
H. Stomata with a single subsidiary cell
I. Anomocytic stomata
J. T. S. epidermis of calyx showing development of paracytic stomata
K. Mature stomata in T. S. (note cuticular hooks)

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L. Hair initial
M-N. Stages in the development of peltate glandular trichome
O. Peltate glandular trichome with 1-celled stalk
P. Capitate glandular trichome
Q. Clavate glandular trichome
R. Fusiform ,, ,,
S. Simple filiform uniseriate trichome
T. Cylindrical trichome
U. Peltate glandular trichome with 2-celled stalk
V. Hooked trichome
W. T. S. passing through the head of a peltate glandular trichome

Fig. 2 (A–J X 690)
A. Sclereid initials
B. Sclereid initial showing contraction of the cytoplasm
C. Stages in the development of sclereids
G-H. Elongated solitary sclereids (note oval structure and granules in G)
I. Group of 2 elongated sclereids
J. Group of polygonal sclereids.

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ONTOGENY OF AXILLARY BUDS IN TRIGONELLA FOENUM-GRAECUM L.

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Abstract

Plastochronic changes of the main shoot apex, and origin, development and vascularization of axillary buds in *Trigonella foenum-graecum L.* are investigated. There are four phases of plastochron, the early pre-leaf initiation, the late pre-leaf initiation, the leaf initiation and the post-leaf initiation. At the end of each plastochron the meristematic part of the shoot apex is raised above the youngest leaf primordium by the activities of cells in subjacent region to central and peripheral meristems. The earliest bud meristem is identified as a bright stained zone of peripheral meristem near the first or second leaf primordium. At the earliest stage it has only one bud trace and later the bud has two traces. There is only one prophyll. The vegetative and floral buds can be distinguished at the earliest stage.

Introduction

The most common visible result of the morphogenetic activity occurring in vegetative shoot apex is the origin and development of the lateral appendages, leaves and axillary buds. Depending upon the development and growth factors correlating the activities of the bud primordium, axis and axillant leaf, the buds develop into lateral branches. The adult lateral branches of the shoot form an important part of the plant which determines its general symmetry and form. Many research workers (Reeve, 1943; Majumdar and Datta, 1946; Miller and Wetmore, 1946; Garrison, 1949a,b, 1955; Gifford, 1951; Kundu, et al., 1952, 1954, 1955, 1957; Shah, 1960; Ramji and Parameswaran, 1961; Tucker, 1963; Marr and Blaser, 1967) have contributed to the understanding of ontogeny of axillary or lateral branches. An investigation on the axillary buds necessarily involves the study of the main apex also, for the majority of axillary buds in dicotyledons originate from the main apical meristem and they finally attain the functional and structural equivalence of the main shoot apex.

Material and methods

Seeds of *Trigonella* were obtained from P. P. Pochas and Sons, Poona, India, and were sown in the winter months of November and December in the

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experimental field. The shoot apices were collected from time to time from the appearance of cotyledons onwards. Fixatives used were FAA and Craff III and dehydration and infiltraution were done in TBA series. The material was cut at 7–8 μ and stained with Regaud's Hematoxylin-iron chloride-tannic acid-fast green combination.

Observations

Quick succession of leaf initiation and early differentiation of bud meristem are the two significant features of the morphogenetic activity of the dome-shaped shoot apex. Four intergrading phases of the plastochron, the early pre-leaf initiation, the late pre-leaf initiation, the leaf initiation and the post-leaf initiation phases are recognized.

The shoot apex at the early stage of pre-leaf initiation phase shows stratification on the flank of the peripheral meristem which is more or less opposite to L_1 leaf. The late stage of the pre-leaf initiation phase of the shoot apex shows stratification up to 4 or 5 layers in the peripheral zone which is more or less opposite to L_1 leaf. Increase in the area of the shoot apex and stratification of its cells at the time of leaf initiation are commonly reported (Gifford, 1950; Sussex, 1955; Shah, 1960). But in *Garrya elliptica* (Reeve, 1942), ' there is a distinct stratified appearance in the corpus following emergence of the most recently initiated primordium '. Before leaf initiation the stratification is less. However, Gifford (1954) associates increased stratification with the maximal area phase in *Garrya elliptica* (Reeve, 1942). In *Trigonella* the diameter/height range is from 107 μ/69 μ to 118 μ/66 μ in the pre-leaf initiation phase.

A further increase in the size of the shoot apex is found at the leaf initiation phase. The diameter/height range is form 121μ/67μ to 127μ/61μ. The stratification is more pronounced. In this phase the leaf initiation is identified by periclinal divisions in a sector of T_2. But as in *Drimys winteri* var. *chilensis* (Gifford, 1951), periclinal divisions in T_2 and corpus occur simultaneously during leaf initiation. Further anticlinal divisions in tunica and divisions in various planes in the corpus build up the leaf primordium.

The shoot apex at the post-leaf initiation phase has a basal diameter/height range of 90 μ/31μ to 102μ/42μ, when measured at the level of the first visible node. Eventhough the two layered tunica divides predominantly by anticlinal divisions, there was a solitary case of a periclinal division in T_1. T_2 shows periclinal divisions in connection with leaf initiation only. The corpus divides in various planes. A poorly defined central meristem is distinguished. Comparatively its cells have greater cytonuclear ratio and less avidity for staining. Usually this zone consists of T_1, T_2 at the summit and a few subjacent corpus cells. The densely stained peripheral meristem is not well stratified. The rib meristem is of vacuolated cells.

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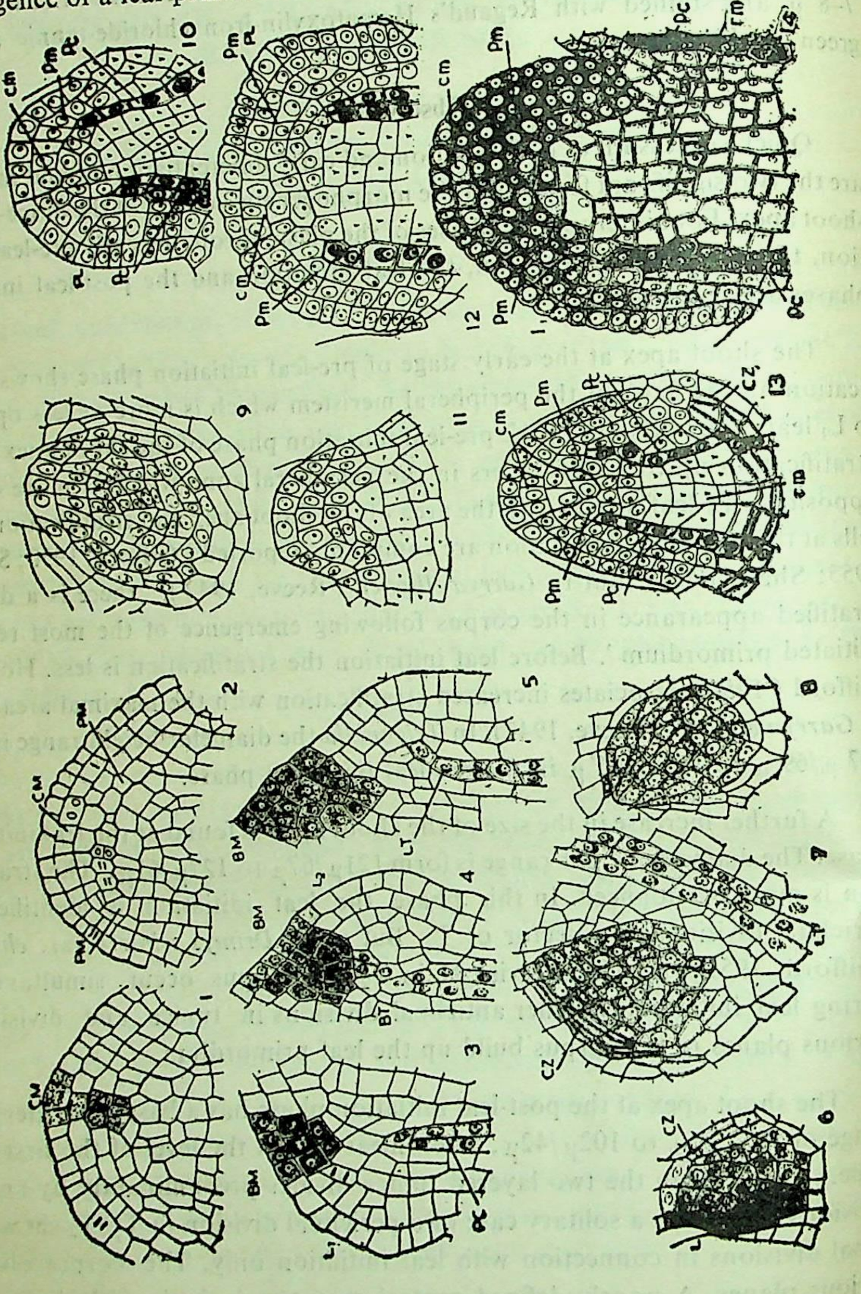
After the initiation of a leaf primordium, the shoot apex above it is raised up prior to the initiation of the next leaf primordium. Following the initiation or emergence of a leaf primordium in *Salix laevigata* (Reeve, 1948) there may



be periclinal divisions in the cells of upper layers of stratified corpus or even in a centrally located cell of the otherwise distinct T_2 layer. In *Drimys lanceolata* (Gifford, 1950), periclinal divisions occur in T_2 of the central zone after the initation of leaf primordium. In *Ephedra altissima* (Paolillo and Gifford, 1961) the

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central meristem zone is raised up by elongation of its lower derivatives during a plastochron. The details of this phase of the morphogenetic activity of the shoot apex during the plastochron, as studied in *Ephedra*, are not available in the literature for many angiosperms. In this regard, the observations on *T. foenum-graecum* need some elaboration.

Figure 1 shows a periclinally divided cell in the third layer of the central meristem. Subjacent cells are elongated. The orientation and thickness of walls suggest that this complex of six cells is derived from a common cell. Figure 2 illustrates some corpus cells dividing periclinally. They are in the peripheral flank where the next leaf is likely to be initiated. In figure 2, one of the central meristem cells can be seen dividing anticlinally. These features shown in figures 1 and 2 suggest that, as reported for *Ephedra*, the elevation of the central meristem after the initiation of a leaf is due to periclinal divisions in the cells of the central meristem followed by elongation of the lower derivatives. The anticlinal divisions in the cells of the central meristem contribute to the growth of the peripheral meristem. But in *T. foenum-graecum*, after the initiation of a leaf, all cells of the peripheral meristem other than those which have already taken part in leaf initiation are raised up by periclinal divisions and elongation of lower derivatives as shown in figure 2.

Origin of the bud

The inception of the bud meristem is observed in the apical meristem adaxial to either the first (Fig. 3) or the second leaf primordium (Fig. 4). It is a densely stained zone. The cells of the young bud meristem, especially cells of T_2 and corpus appear deeply stained. Probably the differential stainability indicates varying morphogenetic potentialities. These cells may show compact alignment (Fig. 4). Figures 4 and 5 show that the bud trace procambium and the trace procambium of the axillant leaf are different. The early bud meristem has only one bud trace. The second bud trace develops later in the development.

Further development of the bud

The bud meristem increases in volume by more anticlinal divisions in tunica and periclinal divisions in corpus. The anticlinal divisions are more along the peripheral side of the bud meristem (Figs. 6, 7). In the initial stages the third and fourth corpus layers of the bud divide periclinally, and corpus cells further below undergo divisions in various planes (figs. 6, 7 ,48, 49).

During further development, this type of irregular divisions are not found as most of the corpus cells divide anticlinally and periclinally (Figs. 8,9,50). This histogenic activity results in the protrusion of the bud meristem (Figs. 8, 9, 51).

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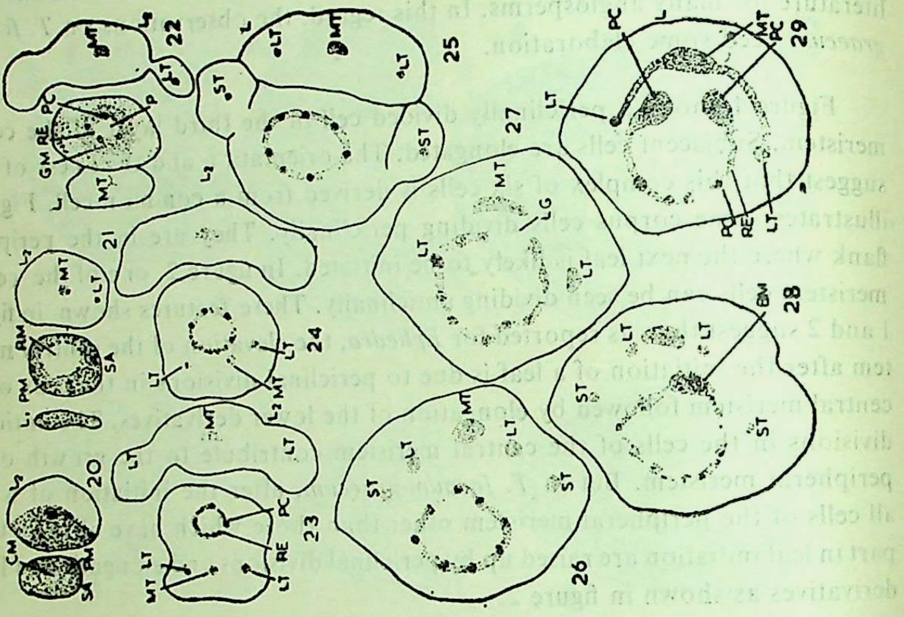
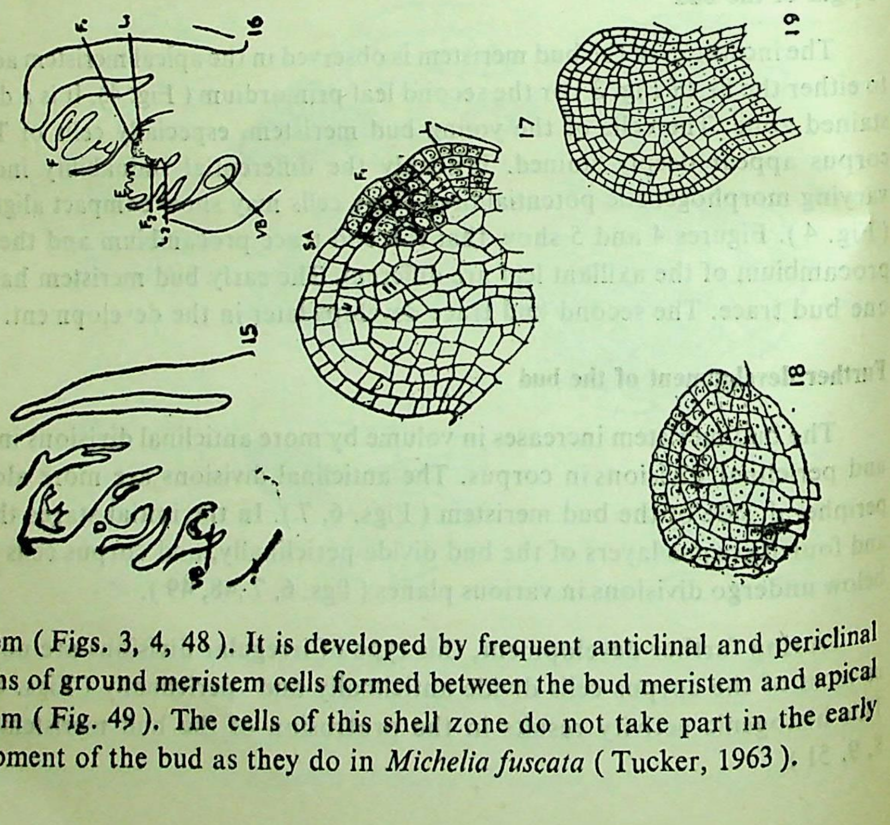
A zone of the cambium-like cells is observed on the adaxial side of the bud meristem (Figs. 6, 7). This zone is not found in the earliest stage of the bud





meristem (Figs. 3, 4, 48). It is developed by frequent anticlinal and periclinal divisions of ground meristem cells formed between the bud meristem and apical meristem (Fig. 49). The cells of this shell zone do not take part in the early development of the bud as they do in *Michelia fuscata* (Tucker, 1963).

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By the time the bud assumes a prominent convexity, it occupies an axillary position (Fig. 9). The corpus cells at the base of the bud vacuolate leaving the apex of the bud as a eumeristematic hood (Figs. 11, 52). In the further stage of development, a less stained central meristem, vacuolated rib meristem and pith cells below it are differentiated (Figs. 10, 13). Two procambial strands are visible (Fig. 13). The shell zone cells gradually lose their identity. They differentiate into cortical parenchyma, procambium and pith cells of the bud (Fig. 13).

The prophyll initiation is identified by periclinal divisions in T_2 or outermost corpus layer of a well developed bud (Figs. 10, 12, 53). Only one prophyll is formed, which is at a right angle to the axillant leaf (Figs. 10, 12, 54, 55). The prophyll is similar to other leaves of the bud. The differentiation of procambial strands for the prophyll and the next leaf is precocious (Fig. 10). The first leaf of the bud is also initiated by periclinal divisions in the sector of T_2 (Figs. 14, 56).

Floral bud

The flowers of *Trigonella* are solitary and axillary. The apex is crowded with floral buds (Figs. 15, 16). The initiation of the flower bud is indicated by a prominant hump (Fig. 17). This is in contrast with the early meristem of the vegetative bud where there is no bulging (Figs. 3, 4). In *Garrya elliptica* (Reeve, 1943) the axillary floret primordium until the emergence of its prophyll is not having histological distinction from the axillary foliage bud in the early stages. In *Trigonella* the difference between vegetative and floral buds is more pronounced in the subsequent stages (Figs. 18, 19). Figure 18 shows a floral bud at the second node where T_1 and T_2 show regular anticlinal divisions, whereas corpus cells have mostly divided by horizontal and vertical divisions so as to make the bud more or less flat. The bud at this stage shows a meristematic cap surrounding the vacuolated region. When the corpus cells divide by various planes, the appearance of the bud shows a marked difference (Fig. 19). At this satge the floral whorls are initiated, and procambial strands are blocked out. The buds shown in figs. 17–19 are related respectively to L_1, L_2 and L_3 leaves from the shoot apex. Their structural prominence will be more striking when compared with the vegetative buds related to L_1, L_2 and L_3 leaves (Figs. 3, 6, 7). In *Trigonella* sometimes the lower bud, VB, remains small and vegetative, while the buds at higher nodes are prominent and floral (Figs. 15, 16).

Early vascularization of the main apex

Transverse sections of a number of shoot apices have been examined. The following description of main apex and bud typifies the general observations. The various levels expressed in μ are calculated by counting the serial sections from one stage to the other.

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A transection slightly below the extreme tip of the shoot apex shows a light stained central meristem, CM, and dense and deep staining peripherla meristem, PM (Figs. 20, 21). Rib meristem, RM, and peripheral meristem, PM, are observed still below. At a depth of 28μ, the cortical part of the ground meristem, GM; procambium, PC; and residual meristem, RE are distinct (Fig. 22). All the three, i.e., the procambium, the residual meristem and the ground meristem are differentiated from the peripheral meristem. The highly vacuolated pith cells, P, are derived from rib meristem (Fig. 19). The procambial cells have narrow lumen and deep staining nucleus and cytoplasm. The residual meristem cells are comparatively bigger and lightly stained. The cells of the ground meristem are more vacuolated than the cells of the procambium and the residual meristem.

The second leaf, L_2, shows its median vascular strand, MT, and one of the two lateral strands, LT, at this level (Fig. 22). The first leaf, L_1, with its median strand, MT, is also seen (Fig. 22). The vacuolation of cells on the abaxial and adaxial sides of a leaf primordium makes the procambial cells in between very distinct. Similarly, in the axis region, the vacuolated cells in the cortex and pith block out procambium and residual meristem in between.

The three vascular strands of L_1 leaf become associated with the axial cylinder of procambium and residual meristem at lower levels (Figs. 23–25). At 147 μ level, the second leaf, L_2, is associated with its two stipules on either side (Fig. 25). Five procambial strands, one median leaf trace, MT, two laterals, LT, and two stipule traces, ST, are present (Fig. 25). At 163 μ level, the stipule trace procambium, ST, shows its connections with the lateral trcae, LT (Fig. 26). Approximately at a depth of 177 μ, the median leaf trace, MT, and one of the lateral traces, LT, are seen with their respective leaf gaps, whereas the other lateral trace has become a part of the axial vasculature (Fig. 27). The node is trilacunar.

The procambial strands are differentiated acropetally. The presence of residual meristem as well as procambium in the shoot apex shows that the peripheral meristem differentiates into residual meristem and procambium.

Vascularization of the bud during prophyll initiation

In the longitudinal section, a single procambial bud trace is observed in the earliest stage of the bud (Fig. 4). It is differentiated from the peripheral meristem of the main shoot apex as the early bud meristem originates from the apical meristem. The procambial strands present in a developing bud are in continuation with the original bud traces which in their early stages were near the base of the bud (Fig. 13). The part of the procambial strand, pc, has its origin in the differentiated cells of the bud meristem, and its distinction from the earlier formed part of the bud trace is recognized by the disappearing identity

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of the shell zone cells (Fig. 13). The distinction between the early bud trace lying at the base of the bud meristem and its extension into the growing bud as a result of differentiation of bud tissue is difficult to make out in a well developed bud. For the convenience of general description, therefore, the definition of branch trace by Esau (1960) is very useful. The branch trace is defined as " a vascular bundle in the main stem extending between its connection with the vascular tissue of the branch and that with another vascular unit in the main stem ". The procambial traces of the prophyll and early leaves have precocious development in the bud. The various stages of procambialization in the bud at successive nodes of the axis are illustrated in figures 28–40.

In a transection the bud meristem appears as a bright stained zone at the second node (Fig. 28). It is closely situated to the axial vasculature. At about 21 μ below the earlier described stage, the edges of the axial vasculature, separated by the ground meristem of the median leaf gap, appear dense and deep stained, suggesting the positions of the two bud traces (Fig. 29). Further down, the median and the lateral leaf traces become a part of the axial vasculature.

The bud at the third node shows the precocious procambial strands for the single prophyll and the first leaf (Figs. 30–34). The course of the bud traces is described from the base of the bud upward. The two bud traces, BT, originate from the axial vasculature, AV (Fig. 30). They develop acropetally into the bud by differentiation of the bud meristem. The procambial strands and the residual meristem differentiated in the bud together constitute the provascular system of the bud, which appears as two arcs at this level (Fig. 31). In each arc there are three procambial strands, the branches of the bud trace strands (Fig. 31). As there is only one prophyll, the procambium on the 'prophyll sector' of the bud is more prominent (Figs. 30, 31). The gradual differentiation and organisation of three strands from a single bud trace are traceable in figures 30 and 31. Above 21 μ, the provascular system of the bud appears as a ring consisting of the precocious procambial traces of prophyll and leaf, and the residual meristem (Fig. 32). At about 35 μ level, the rib meristem, rm; peripheral meristem, pm; and the procambial strands, mp and mt, of the bud are observed (Fig. 33). About 56 μ nearer the bud apex, the less stained central meristem and the bright stained peripheral meristem are seen (Fig. 34).

Similar development of provascular system of the bud at the fourth node is illustrated in figures 35–40. The prophyll initiation occurs at the fourth or fifth node. The bud traces take their origin from the axial vasculature, and at 14 μ level each of them organizes into three strands (Figs. 41, 42). These procambial strands and the residual meristem cells differentiated from bud apex constitute the provascular system of the bud. The provascular system appears semilunar at about 35 μ level (Fig. 43). Still above, it appears as a complete ring in a

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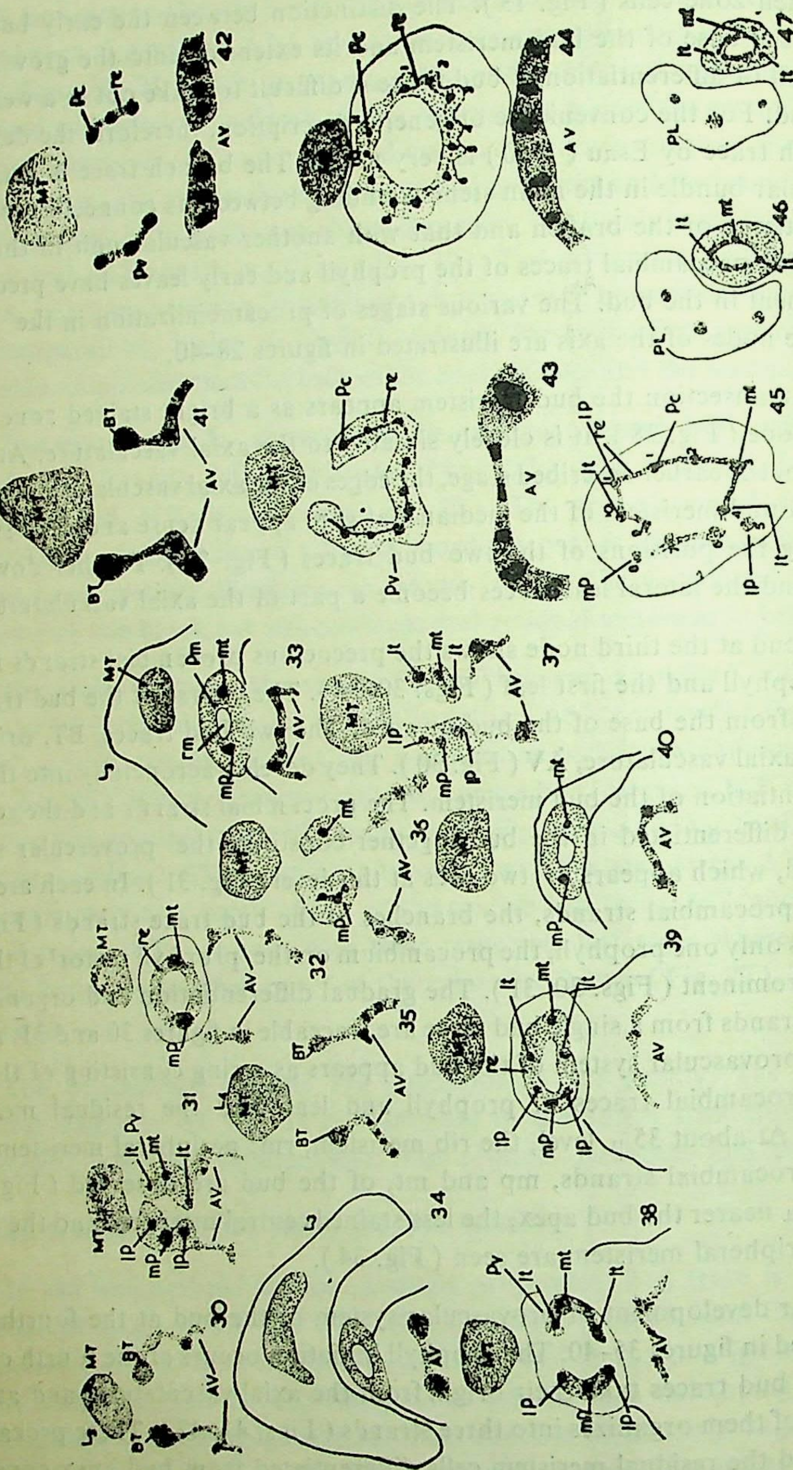

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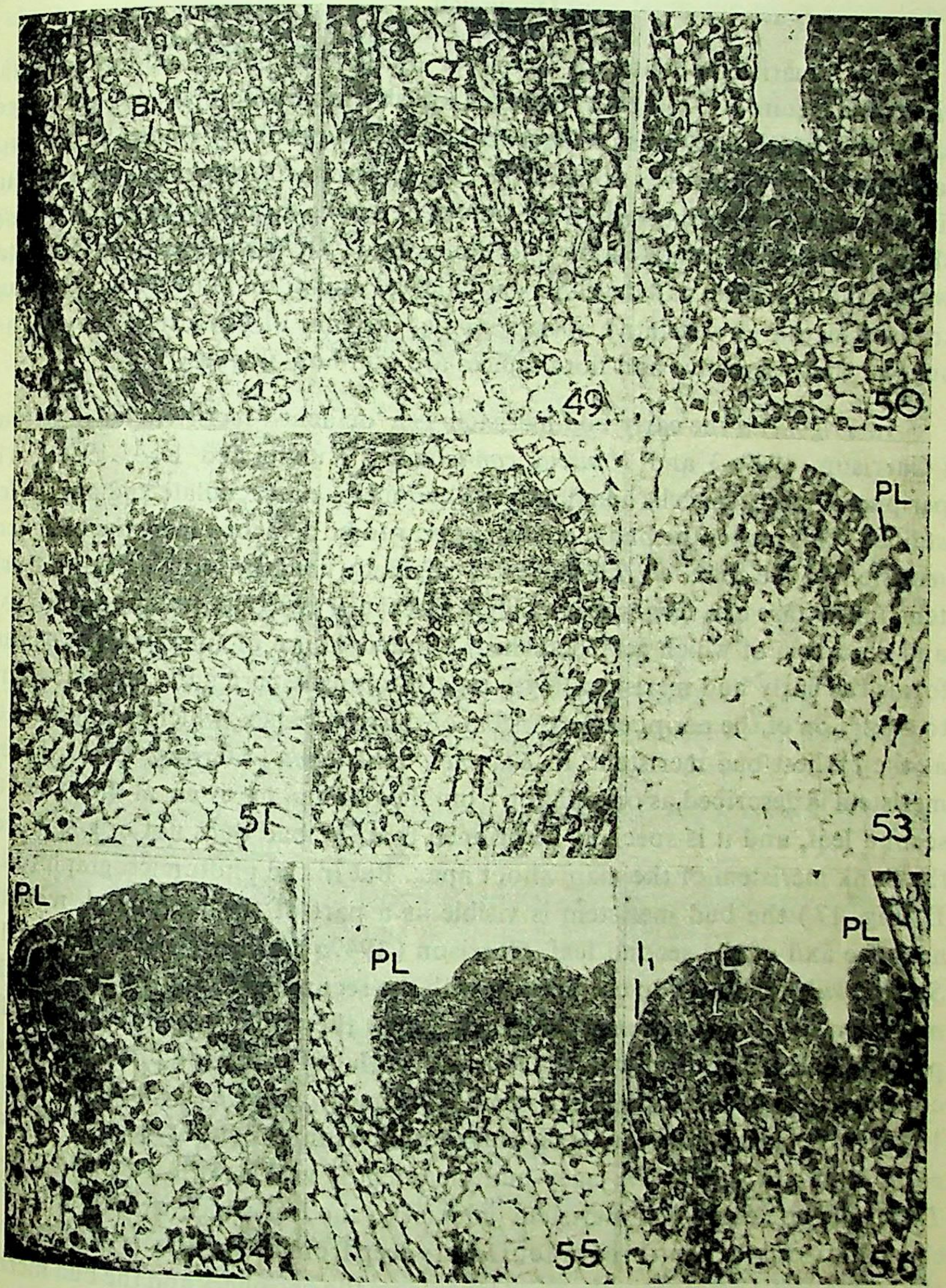
transverse section (Fig. 44). Ten to fifteen procambial strands are present. Of the 11 procambial strands (Fig. 44), 5, 8 and 11 are prophyll traces; while 4,



3 and 10 are the traces of the next leaf as can be seen at higher level (Fig. 45). After the departure of the prophyll traces, the vascular system of the bud shows only three leaf traces; the rest of the provascular system is of residual meristem

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(Fig. 46). Almost near the bud apex, the median and the lateral strands are distinct in the peripheral meristem (Fig. 47).

Discussion

The " meristeme d'attente " concept of the French School supports the view of Gregoire (1938) that the floral apices are non-homologous with vegetative apices. Observations on *Trigonella* neither support the French School nor fall in line with Gregoire's contentions. The central meristem is active in vegetative phase in the present case. At the time of flowering the main apex of *Trigonella* shows increase in stratification and dimensions. These changes are associated with rapid initiation and development of leaves and floral buds. Thus, a gradual transformation of vegetative apex is seen at the time of flowering. They do not suggest that vegetative and floral apices are non-homologous.

In *Trigonella* the early bud meristem is a 'detached meristem' as in *Syringa* (Garrison, 1949*a*) and *Hibiscus cannabinus* (Kundu and Rao, 1955). The peripheral meristem cells adaxial to the bud meristem vacuolate and appear less stained. This makes the bud meristem appear to be detached from the peripheral meristem of the apex. Wardlaw (1943) originally used the term 'detached meristem' in the case of a fern where a single apical cell gives rise to lower derivatives and a portion of which gets 'detached' by vacuolation of surrounding cells and forms the early bud meristem. With regard to angiosperms the term is referred to a portion of the peripheral meristem of the shoot apex, which is differentiated as the earliest bud meristem. In *Dianthera americana* (Sterling, 1949) the bud meristem is described as originating from the residual meristem at the axil of the second leaf, and it is specially mentioned that the bud does not originate from the flank meristem of the main shoot apex. But in the photomicrograph (Plate II, Fig. 17) the bud meristem is visible as a part of the peripheral meristem near the axil of the second leaf. Garrison (1949*a*) interprets the early bud of *Syringa vulgaris* found in connection with the second or third leaf as a detached meristem. In *Drimys winteri* (Gifford, 1951) the axillary bud activity is first percetible in connection with the fourth or fifth leaf primordium, and the bud is considered as a 'detached meristem'. The buds of *Juglans cinera* (Garrison, 1955) arise from the residual meristem derived from the shoot apex. In *Cayratia carnosa* (Shah, 1960) the early bud meristem is visible with leaf initiation. In *Trigonella* the early bud meristem adaxial to the leaf which is initited by periclinal divisons in T_2 is three or four layers deep from the periphery. Occasionally the leaf initiation occurs in the third layer from the periphery and the bud meristem adaxial to it is four or five layers deep.

It will be better if the term "detached meristem" is used with greater distinctness. If the metabolic changes bringing about the histologic differentiation of bud

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meristem occur in a sector of apical meristem itself, and if such a bud meristem is gradually separated from the apex, the term "detached meristem" should be preferred. On the other hand, if the earliest bud meristem is discernible near the axil of a leaf histologically away or more remote from the main apex, the term "detached meristem" may not be used.

The differentiation of bud traces is acropetal. When procambia are differentiated in the bud as a continuity of the bud traces, they form bracket-shaped or arch-shaped configuarations of provascular system of bud. This provascular system is made up of procambium and residual meristem. These configurations have been named as bud traces by different authors (Garrison, 1949*a*, *b*; Miller and Wetmore, 1946; Kundu and Rao, 1955).

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EXPLANATION OF FIGURES

Plate I :

Figs. 1–14. Fig. 1. L. S. vegetative shoot apex, note a complex of central meristem, X 600. Fig. 2. L. s. vegetative shoot apex, note the anticlinal and periclinal divisions in the cells of central meristem and peripheral meristem zones, X. 600. Figs. 3–5. Early bud meristem, X 600. Figs. 6–8. Bud development by increased

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activities of corpus, X 600. Figs. 9–10. Evagination of the bud, X 600. Fig. 11. Cytohistological zones in the bud, X 600. Figs. 12–13. Initiation and formation of the single prophyll butteress, X 600. Fig. 14. Initiation of bud leaf, X 600. BM, bud meristem; BT, bud trace procambium; CM, cm, central meristem; CZ, zone with cambium-like cells; L, leaf; L_1, L_2, L_3 leaf primordia; l_1, leaf of the bud; LT, leaf trace; pc, procambium; PM, pm, peripheral meristem; PL, prophyll; rm, rib meristem; 'v' represents vacuolated cell.

Plate II :

Figs. 15–29. Fig. 15. Apex with floral buds, X 60. Fig. 16. Shoot apex with first and second axillary floral buds, X 60. Fig. 17. Shoot apex with first floral axillary bud and leaf, X 600. Fig. 18. Second axillary floral bud, X 600. Fig. 19. Floral bud just before organogenesis, X 300. Figs. 20–27. T. s. young shoot, X 260. Figs. 28–29. T. s. second node, X 260. BM, bud meristem; CM, central meristem; D, E, F, F_1, F_2, floral buds; GM, outer part of ground merstem; L_1, L_2, leaf primordia; LG, leaf gap; LT, lateral leaf trace, MT, median leaf trace; PC, procambium; PM, peripheral meristem; RE, residual meristem; SA, shoot apex; ST, stipule trace, VB, vegetative bud; 'v' represents vacuolation.

Plate III :

Figs. 30–47. Figs. 30–34. T. s. third node. Note the origin of bud trace and its upward in the bud, X 235. Figs. 35–40. T. s. fourth node, X 235. Figs. 41–43. T. s. bud with prophyll, X 235. Figs. 44–47. More branches of procambium strands in the bud and the origin of prophyll—and leaf trace procambium, X 235.

AV, axial vasculature; BT, bud trace; L_3, L_4, third and foruth leaves; lp, lateral prophyll trace; lt, lateral trace of bud leaf; mp, median prophyll trace; MT, median trace of axillant leaf; mt, median prophyll trace; PL, prophyll; pc, procambium; pv, provascular system; re, residual meristem; 1–11, different procambial strands.

Plate IV :

Figs. 47–55. Figs. 47–51. The evagination of the bud, note the arrows pointing towards the disappearing cambium-like zone, X 210. Figs. 52–54. The origin and development of prophyll primordium, X 210. Fig. 55. Origin of first bud leaf, X 210.

CZ, cambium-like zone; l_1, first bud leaf; PL, prophyll.

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ADDITIONS TO THE FLORA OF GUJARAT; NEW LOCALITIES FOR THE PLANTS; NOMENCLATURE CHANGES

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INTRODUCTION

In order to have a better knowledge about the flora of Gujarat, it is imperative to study as many areas of the State as possible. The author has, therefore, been exploring the different parts. The outings have helped in (*i*) collecting plants which are, so far, not reported from Gujarat, and (*ii*) finding the new localities for those plants which are supposed to be rare or restricted in distribution. After a critical study of plants collected, the observations, wherever are different from those in published literature, were noted down. All this information is compiled as an humble contribution towards the preparation of the FLORA OF GUJARAT. The present paper is in continuation of the previous ones (*Shah and Inamdar*, 1966; *Shah and Patel,* 1967).

Most of the plants, accounted for, are collected from Kevadia, Garudeshwar, Surpaneshwar, Dediapada and Sagbara in the Rajpipla forest range and occasional ones are from Dangs, Vyara, Ubharat and Broach, all in South Gujarat; Baroda, Vasad, Tuwa and Pavagadh in Central Gujarat and Mahudi and Derol in North Gujarat. The relavent collection numbers with collector's name (underlined) are given at appropriate places in the text. The collection is in the herbarium of the Botany Department, Sardar Patel University, Vallabh Vidyanagar.

The nomenclature of the plants is mostly that of Cooke (1958), but where it is changed, the name appearing in Cooke's FLORA is given in the brackets. For details on nomenclature see Raizada (1958, 1966, 1968), Santapau (1967) and Santapau and Janardhanan (1967). *Albizia amara* Boivin, *Cyperus malabaricus* Clke., *Mazus pumilus* Steenis, *Rhynchospora wightiana* Steud. and *Scirpus kyllingioides* Boeck. are additions to the flora of Gujarat.

MALVACEAE

Malachra capitata Linn.

The plant is a native of Brazil, introduced in India by late Mr. Nimmo. In Bombay and Salsette Islands it is one of the commonest weeds, often growing

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almost in pure stands for long stretches along road sides and railway lines, in the rainy season. Santapau (1962) seems to be the only worker to report it from Junagadh. To this the locality Ubharat is added, where it is common on edges of cultivated fields along roads (*Shah*, 14444). It yields a very good fibre which is used as a substitute for jute. The specific name " *capitata*" probably refers to a head-like, terminal inflorescence of 4–8 yellow flowers, subtended by foliaceous involucral bracts, on 2·8-9 cm long peduncle.

Senra incana Cav.

Though this plant has been occasionally met with in Sabarmati ravines near Derol, it is one of the conspicuous plants in the area by its bright yellow or orange-coloured flowers. It is not recorded by Saxton and Sedgwick (1918) and, so far, its known distribution in Gujarat is Saurashtra (Santapau, 1962). It was noted in flowers in the first week of September, 1967, though the flowering periods, according to Cooke (1958) and Santapau (1962), are November-January and October–April respectively. It may be mistaken for *Abutilon* sp. at the first sight, but deeply cordate, foliaceous, involucral bracts, three in number, are distinctive.

STERCULIACEAE

Eriolaeana stocksii Hk.f. and Th.

The occurrence of this plant in Bombay Presidency was, so far, doubtful as Cooke (1958) remarked, "This species is scarcely distinct from *E. hookeriana* W. and A. and it is impossible to say in absence of frutis, whether the species should be maintained as separate or united with *E. hookeriana* W. & A. In the revision of the flora of Bombay Presidency, after consulting all the available literature, Blatter (1931) expressed an opinion that E. *stocksii* should be altogether dropped from the flora of Bombay. But this view is now not shared by Shah and Suryanarayana* who gave a full account of it on the basis of fruiting specimen collected from Dangs in October and flowering specimen (herbarium sheet, Dalzell N.J. No. 142939, loc. Bombay Pres.) in the Forest Research Institute, Dehradun. It is indeed a very rare plant in Dangs forest, found in Malegaon-Saputara hill range, and it grows on such spots, which, at any rate are accessible only with difficulty. Recently a few plants were seen in flowers (June) and fruits (July) from Dediapada and Ghantoli forests (*Singh*, 2026).

TILIACEAE

Grewia hirsuta Vahl

It is distributed in Modasa (*Saxton and Sedgwick*, 1918) and Saurashtra (*Santapau*, 1962). The later author has included it in his flora on the authority

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of Indraji and Ahluwalia. In South Gujarat it is common, scattered or in loose patches, in the undergrowth of the forests and in open grasslands on the edges of the forests at Dediapada (*Shah*, 13069), the only locality, so far known for its distribution in South Gujarat.

LINACEAE

Linum mysurense Heyne ex Roth

So far it is found in hilly region of Pavagadh (Chavan and Oza 1966; Shah and Inamdar, 1965). In December 1967 (*Shah*, 11915) it was collected from the moist alluvial beds of river Narmada at Gora where it was fairly common with *Bergia ammannioides* Roxb., *Gnaphalium indicum* L. and *Sutera dissecta* Del.

ROSACEAE

Pontellia supina Linn.

Prostrate herbs with radially spreading branches. Flowers yellow. Common with the previous species in Narmada river bed at Gora (*Shah*, 11915, 13025). Earlier reports of its occurrence from Gujarat are also from the areas situated along Narmada river banks e.g. Karnali (cf. Cooke, 1958), Broach (*Shah*, 1964) and recently along margins of a pond on way to Machi at Pavagadh (*Shah*, 14496).

MIMOSACEAE

Acacia nilotica (L.) Willd. ex Del. ssp. *indica* Brenan (*Acacia arabica* auct. non willd).

This is the correct name for our Indian plant which commonly goes under the name *Acacia arabica* in most of our floras. (See Brenan in *Kew Bull*. 1957 : 84, 1957 and *Fl. Trop. E. Afr*. 109, 1959). The ssp. *indica* is characterised by " pods necklace-like, grey-white, tomentellous, narrowly and regularly constricted between the seeds".

Albizia amara (Roxb.) Boivin

Trees 5–8 m tall; bark rough, brown. Seen only fruits in December, 1966 at Gora (*Shah*, 13008). According to Brenan in *Kew Bull*. 1955 : 189, 1955 the Indian plant is ssp. *amara* which can be recognised by the following characters : " Pinnae and leaflets comparatively few, former 4–12 (–16) pairs, latter 10–29 pairs; leaflets 3–7.5cm. long, 0.75–1.5 (–2) mm. wide, often glaucous beneath when mature, lateral nerves, especially the basal, rarely slightly beneath".

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LOGANIACEAE

Cynoctonum mitreola (L.) Britt. (*Mitreola oldenlandiodes* Wall.)

This tiny herb is rather interesting from the view-point of its distribution in Gujarat, so far recorded from Lunawada (*Saxton*, 1922) and Pavagadh (*Shah and Inamdar*, 1965). It is a very rare plant in the later locality. However, during a recent botanical excursion to Sagbara it was fairly common in cultivated fields and in the rocky undergrowth of forests (*Shah*, 14137). For the nomenclature of this plant see Shah (1963).

OLEACEAE

Nyctanthes arbortristis Linn.

The plant is truly wild, fairly common and abundant on the hilly slopes in vicinity of Gora, Kevadia and Surpaneshwar (*Shah*, 13010). It has also been reported wild by Saxton and Sedgwick (1918) near Modasa and southwards to the Vatrak river. The present report is, however, interesting in light of Cooke's remarks (1958). " It is doubtful if the plant is truly wild in the Bombay Presidency; indeed Roxburgh says that he has never met it at all except in a cultivated state. Dalzell says, " he recollects to have seen it wild in the Satpura forests near Arwad in Khandesh, whence it has also been obtained by Woodrow. "

The hills in Rajpipla forests near Kevadia, Gora and Surpaneshwar are the extensions of Satpura ranges and the limit of Gujarat State meets at Surpaneshwar with the boundry of Khandesh in Maharashtra State. The present record, therefore, substantiates the observations of Dalzell.

CONVOLVULACEAE

Convolvulus rottlerianus Choisy

This is an attractive plant when in full bloom by its bright rosy-purple flowers. It is so far listed from Saurashtra (*Santapau*, 1953). The locality Pavagadh (*Shah*, 13049) is added to it, where only one plant was seen on grassy slopes in a patch of *Triumfetta rhomboidea* Jacq. It is not recorded by Chavan and Oza (1966) from that area.

Merremia hederacea (Burm. f) Hall. f (*Merremia chryseides* Hall. f.)

Chohan, Inamdar and Deshpande (1966, p. 210) have reported it from Vallabh Vidyanagar under *M. chryseides*. Recently Shri M. H. Patel also collected it from Gamadi, a village about 1.6 kms, east of Anand, where it is common on hedges. Santapau and Janardhanan (1967) list it from Saurashtra under

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the correct name *M. hederacea* (Burm. f.) Hall. f. The flowers are smallest for the genus. The correct nomenclature is as follow :

Merremia hederacea (Burm. f.) Hall. f. in Engler, Bot. Jahrb. 18 : 118, 1893; *Ooststroom* in Fl. Males 4(4) : 441, t. 23 a-b, 1953; Verdcourt in Fl. Trop. E. Afr. (Convolvulaceae) 54, 1963. *Evolvulus hederaceus* Burm. f. Fl. Ind. 77, t. 30, f. 2, 1768. *Ipomoea chryseides* Ker-Gawl in Bot. t. 270, 1818. *Merremia chryseides* (Ker-Gawl) Hall. f. in Engler, Bot. Jahrb. 16 : 552, 1853; Clarke in Hooker's Fl. Brit. India 4 : 206, 1883; Cooke, Fl. Pres. Bombay 2 : 307, 1958.

The nomenclatural adjustment has to be made according to the Rule of Priority. *Evolvulus hederaceus* Burm. f. (1768) and *Ipomoea chryseides* Ker-Gawl (1818) are two basionyms, but the former name, as it is validly and effectively published, has a priority and the plant must be called *Merremia hederacea* (Burm. f.) Hall. f.

SCROPHULARIACEAE

Mazus pumilus (Burm.f.) Steenis

Tiny herbs, 10–30 cm tall. Rare in the alluvial river bed of Narmada at Gora (*Shah*, 11923). Flowers pale blue to almost white.

Torenia indica Saldhana (*T. cordifolia* auct. non Roxb.).

Herbs with pale blue flowers. The winged calyx is a distinctive feature of the genus. While working on Scrophulariaceae of Western India, Saldhana (*Bull. bot. Surv. India* 8(2) : 126, 1966) collected the present species from Waghai, the sole locality, so far, known for its occurrence in Gujarat. To this, the localities Dediapada (*Shah*, 14021) and Sagbara (*Shah*, 14141) are added. According to Saldhana (l.c.) the Western Indian plant has been wrongly confused in our flora with *T. cordifolia* Roxb. *T. indica* Saldhana and *T. cordifolia* Roxb. differ as follows :

Leaves heart-shaped; calyx not cordately winged, 2 lipped; upper lip 3-toothed, lower one simply pointed .... *cordifolia.*

Leaves cuneate at base; calyx cordately winged, two-lipped, upperlip 3-toothed, lower 2-toothed .... *indica.*

POLYGONACEAE

Polygonum barbatum L. var. **gracile** Steward (*Polygonum serrulatum* Hk.f.)

Within the limits of Gujarat it was first recorded by Saxton and Sedgwick (1918), under *P. serrulatum* Hk. f. Recently Inamdar (1968) reported it from

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Dharampur under the correct nomenclature. In my experience it is a common plant at Rajpipla and Vyara forests (*Shah*, 14298) where it grows gregariously near water courses in river beds and ditches, either by itself or mixed with *Polygonum glabrum* Willd. The two species are often confused but apparently light pink to almost white flowers seem to be distinctive of *P. barbatum* var. *gracile* Steward. The following are the detailed characters by which they can be separated:

Stem dirty reddish-purple, not polished; leaves roughly strigosely hairy; stipules strigosely pubescent, ciliate with long hairs; bracts ciliate; styles 3; fruit trigonous ...... *P. barbatum* var. *gracile.*

Stem reddish-purple, polished, with a dark reddish-brown ring at each node; leaves glabrous; stipules glabrous, truncate; bracts eciliate; styles 2; fruit biconvex ...... *P. glabrum.*

For the nomenclature of this plant see Steward *contrib. Gray Herb.* 88 : 55, 1930.

LORANTHACEAE

Dendrophthoe falcata (L.f.) Etting. var. **coccinea** Santapau (*Loranthus longiflorus* Desr. var. *coccinea* Talb.).

This variety is one of the most conspicuous parasites by the masses of deep red or scarlet flowers. It was first reported on *T. bellirica* (Gaertn.) Roxb. by Talbot from N. Kanara (cf. Cooke 3 : 43). Since then Santapau (1953 and 1967) reported it from Saurashtra and Khandala respectively. It is, however, interesting to note that in Rajpipla and Vyara forests only this variety is found, common on *Tectona grandis* L. f. and *Terminalia crenulata* Roth. It has also been occasionally noted on *Boswellia serrata* Roxb. and *Dalbergia latifolia* at Gora and *Xeromphis spinosa* Keay at Mahal in Dangs.

EUPHORBIACEAE

Phyllanthus lawii Grah.

Tall, slender, bushy shrubs, 1–2 m high; stem and branches deep purple. Common and abundant, in pure stands or mixed with *Tamarix ericoides* Rottl. along water courses in Narmada river — — bed at Garudeshwar and Surpaneshwar (*Shah*, 12022).

These are additional localities of its distribution (cf. *Shah*, 1964). As far as the author is aware, it is, so far, not reported from any other locality in Gujarat.

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ALISMATACEAE

Sagittaria sagittifolia Linn

Chavan and Padte (1960) recorded it for Gujarat from Savli and its environ. Recently it was collected from Surpaneshwar where it is rare, occurring in water/-logged soil (*Shah*, 13002). The leaves are typical. Flowers white.

CYPERACEAE

Cyperus malabaricus Cooke

Slender herbs, 15–30 cm. tall. Spikelets deep chocolate-brown. Common among grasses at Ahwa, Dangs (*Suryanarayana*, 206).

Flowers and fruits : September.

Cyperus nutans Vahl var. **eleusinoides** (Kunth) Haines

This is a common sedge, often gregarious, in water-logged soil and near water courses in many parts of Gujarat (Tuwa : *Deshpande*, 1466; Rajpipla *Shah*, 11459, 2020).

In Cooke's Flora it goes under the name C. *eleusinoides* Kunth. Haines (*Bot. Bihar and Orissa* 3 : 941, 1961, reprinted) has treated it as a variety of *C. nutans* Vahl, with a remark " This seems to be a mere form of *nutans* with more fascicled, denser, shorter spikes and with denser umbels .... and the nut as obovate—oblong, fuscus etc. is almost exactly as in nutans ...... ". Kern also seems to share the same view as can be ascertained from his remarks on one of our herbarium sheets " better treated as a variety ".

Cyperus pangorei Rottb.

Perennial herbs, 60–90 cm tall; common in moist places and near water courses (Vasad : *SNW* 161; Gora : *Shah*, 11948; Garudeshwar : *Shah*, 12020, Dediapada : *Shah*, 11566; Dangs : *Suryanarayana*, 493). The correct name for the present plant, which is *C. tegetum* Roxb. in Cooke's Flora, is *C. pangorei* Rottb. Chavan and Sabnis (1967), who report it from Dangs forest cite *C. corymbosus* as a synonym. However, Santapau (1967) has clearly shown that the two plants are distinct and differ in the following characters :

Rhizome shortly creeping; scales somewhat remote, oblong-elliptic, rufous .... *pangorei.*

Rhizome long-creeping, often stoloniferous; scales mostly densely imbricate, broader, dark or blood coloured .... *corymbosus.*

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Eriophorum comosum Wall.

Tufted herbs; spikelets brown. Rare but locally abundant on hilly slopes on way to Dhirkhadi near Gora (*Shah*, 13007). *Flowers and fruits :* August to December.

This is an interesting plant from the view-point of its distribution in Gujarat State. Sabnis (1962), who has revised the Cyperaceae of Gujarat on the basis of collections made from several localities including Pavagadh and Rajpipla forests has failed to locate it even once. He remarks " *Eriophorum comosum* Wall., though not collected by the author even after intensive search, has been included on the authority of Woodrow, who cites Champanir or possibly fort Pavagadh as the sole locality for this plant ". This implies that it is doubtfully found within the limits of Gujarat. However, the records from Pavagadh (*Shah and Inamdar*, 1965), Saurashtra (*Santapau and Janardhanan*, 1967) and the present locality, therefore, confirm its occurrence in the State; but it seems to have a restricted distribution at present.

Fimbristylis bisumbellata (Forsk.) Bub. (*F. dichotoma* Sensu Clarke in Fl. Brit. India 6 : 635, 1893, non Vahl).

The present author collected this species from Mahudi (*Shah*, 11708), Baroda (*Shah*, 3000–3003); Broach (*Shah*, 1896, 4348) and Vyara (*Shah*, 14307). It is common in moist ground along ditches, and margins of ponds, in river beds, etc. However, the nomenclature is very interesting.

The names of the two plants *F. dichotoma* Vahl and *F. diphylla* Vahl in the literature (Cf. Clarke, 1893; Cooke, 1958; Sedgwick, 1918; Saxton and Sedgwick, 1918; Sabnis; 1962) has to be changed on the Rule of Priority, on the following grounds (from personal communication of Dr. Kern J. H.).

" The plant on which Linnaeus based his *Scirpus dichotomus* is the plant called *F. diphylla* in the *Flora of British India*. Consequently *F. diphylla* should be called *F. dichotoma* (L.) Vahl, based on *S. dichotomus* and the correct name of *F. dichotoma* Sensu Clarke, Fl. Br. India p.635 is *F. bisumbellata* (Forsk.) Bub. Dodec. (1850) 30, based on *Sc. bisumbellatus* Forsk. Fl. Aeg. Arab. (1775) 15 ".

Fimbristylis miliacea (L.) Vahl (*F. quinquangularis* Kunth)

Annuals, 30–40 cm tall; spikelets reddish to dark brown; occasional among grasses and in most river beds (Tuwa : *Deshpande* 271; Garudeshwar : *Shah* 12026: Vyara : *Shah*, 14404, 14405).

The names of *F. miliacea* and *F. quinquangularis* in Cooke's flora have to be changed also, as a matter of Rule of Priority. The following is the excerpt from the letter of Dr. Kern (Personal communication) to explain the nomencla-

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tural situation. "As long as 1894 Clarke stated that the sheet marked (Scirpus) " miliaceous " in Linne's hand is *F. quinquangularis* (Vahl) Kunth. In the same cover in the Linnean Herbarium there is another sheet containing the plant called *Fimbristylis miliacea* in the *Flora of Brit. India* and in numerous other publications, but this sheet does not bear an annotation of Linneaus.

Strictly applying the Rules, S.T. Blake (1954) took the consequences of this fact and accepted the binomial *F. miliacea* (L.) Vahl as an earlier synonym for *F. quinquangularis*. So *Fimbristylis miliacea* (L.) Vahl, En. 2 (1806) 287 =*F. quinquangularis* Kunth, En. 2(1837) 229; Clarke, Fl. Br. Ind. 6(1893) 644; Cooke[1] 3 : 397.

Fimbristylis littorales Gaudich in Freye. Voy. Bot. (1826) 413 =*F. miliacea* sensu Clarke in Fl. Brit. Ind. 6(1893) 644; Cooke[1] 3 : 39 omne non *Scirpus miliaceus* L. ".

Rhynchospora wightiana Steud.

Tiny herbs, 10–15 cm tall; spikelets reddish-brown in a terminal head. The occurrence of this plant within the limits of Gujarat was first reported by Shah and Suryanarayana (1967) from Dangs and as far as author is aware, it is, since then, not recorded : The other known locality for its distribution is Shamalaji hills (Shah without number), collected on 2–9–1967. In both the places it is a rare plant.

Scirpus kyllingioides Boeck

Sedgwick (1918, p. 202) remarks " I exclude *S. kyllingioides* Boeck. given by Cooke on the authority of words " Kanara young " in FBI. No specimens are available either in Cooke's time or now. But there is no reason why the plant should not be found ". The present report of its occurrence from Tuwa (*Deshpande*, 157) and Dangs (*Suryanarayana* 1328) is, therefore, interesting.

Scirpus lateriflorus Gmel. (= S. *supinus* sensu Fischer. non L. 1753; Cooke 3 : 406).

To the known localities for the distribution of this plant under *S. supinus*, I add Ubharat (*Shah*, 14473), where it is occasionally found on moist sandy shores.

Scirpus littoralis Schard. var. **subulatus** (Vahl) Chiov. (= *S. littoralis* sensu Clarke in FBI 6 : 1893, non Schrad.).

Slender herbs, 60–75 cm tall with brown spikelets (Garudeshwar : *Shah*, 12025; Vasad, *SNW* 267).

1. The reference to Cooke is inserted by me.

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The nomenclatural change has to be adopted as *S. littoralis* does not cccur in India, its distribution being from Europe to Central Asia. Only the var. *subulatus* is found in India, Pakistan, Cylon, Iraq, Iran, Australia, Malaysia and Micronesia.

SUMMARY

In the present paper critical observations on 27 species are recorded; of them five are additions to the flora of Gujarat. Wherever possible nomenclautural changes are also explained.

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INHIBITION OF THE CORROSION OF 63/37 BRASS IN CITRIC ACID

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Abstract

Pyrogallol, tannin, gelatine, acacia, dextrine and agar-agar have been investigated as inhibitors for the corrosion of 63/37 brass in citric acid; of the substances investigated, agar-agar is most effective inhibitor.

Uhlig[1] reported that citric acid attacks copper/zinc alloys at a rate of 0.002 ipy. While this corrosion rate is rather low, it is sometimes considered to be too high for food stuffs due to the cumulative effect of metal ions. Desai and Trivedi[2] reported that in 60/40 brass, the corrosion concentration curve reaches a maximum and then decreases, which may be due to the opposing influences of decrease of solubility of oxygen and increase in acidity. They further add that the higher corrosion of 70/30 brass in citric acid may be due to the selective formation of copper citrate which occurs only at high concentration of citric acid[3].

Talati[4] reported that brass specimen exposed to dilute citric acid solutions are covered with reddish green or greenish films which dissolves with blackening in 5% sulphuric acid. However, in concentrated citric acid solutions, there is a slight loose film formation on some parts of the specimen, whereas the rest of the specimen remains bright metallic and slightly etched; the solutions are coloured blue. He further added that 59/41 brass shows a slight tendency for dezincification, whereas in 80/20 brass several instances of dezincification were noted at higher concentration of citric acid.

Desai[5] et. al. reported that the corrosion of 70/30 brass in 0.2N citric acid solution is retarded by various colloids, the order of efficiency being :

Gum arabic > egg albumin / dextrin > gelatine / potato starch > agar-agar

It is explained that decrease in corrosion is due to the adsorption of colloid on the metal surface and the formation of a protective layer.

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Desai[6] investigated gelatine as an inhibitor for the corrosion of 70/30 brass in 0.2N citric acid. The inhibitor influences both cathodic and anodic polarisation, the latter somewhat strongly. Potential and polarisation studies indicate the formation of an adsorbed layer on both cathodic and anodic areas, thus reducing corrosion.

63/37 brass supplied by M/s. Kamani Metals and Alloys, Bombay, was used for the experiments. The preparation of specimens (6 cm. × 3 cm. thickness 28 S.W.G.), corrosion tests, and cleaning of the specimens after corrosion were carried out as described in our previous publications.[7]

OBSERVATION

The percentage inhibition of corrosion of the brass in citric acid by the substances investigated is given in Table 1.

TABLE I

63/37 Brass **Citric Acid**

Inhibitor concentration	*Weight loss of specimen (mg / dm²) and % inhibition for an immersion period of 5 days; (Values in the bracket represent % inhibition)*		
	0.2 N	0.5 N	1.0 N
Nil 0.0%	112.2	100.0	68.7
Pyrogallol 2.0%	51.0 (54.6)	44.9 (55.1)	44.3 (35.5)
Tannic Acid 2.0%	46.5 (58.6)	41.0 (59.0)	59.5 (13.4)
Gelatine 2.0%	43.5 (61.2)	37.4 (62.6)	37.4 (45.5)
Gum Arabic (Acacia) 2.0%	45.1 (59.8)	53.5 (46.5)	33.5 (51.2)
Dextrin 2.0%	64.0 (42.9.)	47.1 (52.9)	39.0 (43.2)
Agar–Agar 2.0%	17.7 (84.2)	44.0 (56.0)	34.6 (49.6)

Low concentrations of pyrogallol accelerate the corrosion of brass in citric acid. At 2.0% concentration of pyrogallol the corrosion of brass in 0.2 N 0.5 N and 1.0 N citric acid solutions is retarded respectively to an extent of 54.5%, 55.6% and 35.5%.

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Low concentrations of tannin accelerate the corrosion of brass in citric acid. Tannin is not at all effective in 1.0 N citric acid solution. At 2.0% concentration of tannin, the corrosion of brass in 0.2 N, 0.5 N and 1.0 N citric acid solutions is retarded respectively to an extent of 58.6% 59.0% and 13.4%.

The efficiency of gelatine is in the order of 0.5 N, 0.2N and 1.0 N. In 0.5 N citric acid the efficiency remains constant beyond 0.5% concentration of gelatine, the efficiency at 0.5% concentration being 62.6% whereas in 0.2 N citric acid solution, 61.2% inhibition is obtained at 2.0% concentration of gelatine and in 1.0 N citric acid solution the efficiency at 2.0% concentration of gelatine is 45.5%.

At 1.0% concentration of acacia, the protection of brass in 0.2 N, 0.5N and 1.0N citric acid solutions is practically the same, however, at 2.0% concentration of acacia, the corrosion of brass in 0.2N, 0.5N and 1.0N citric acid solutions is retarded respectively to an extent of 59.8%, 46.5% and 51.2%.

Dextrin is more effective in 0.5N citric acid as compared to that either in 0.2N and 1.0N citric acid solutions. At 2.0% concentration of dextrin, the corrosion of brass in 0.2N, 0.5N and 1.0N citric acid solutions is retarded respectively to an extent of 42.0%, 52.9% and 43.2%.

The efficiency of agar-agar decreases with the concentration of citric acid. The efficiency of agar-agar increases with the concentration of agar-agar and at 2.0% concentration of agar-agar, the corrosion of brass in 0.2N, 0.5N and 1.0N citric acid solutions is retarded respectively to an extent of 89.2%, 56.0% and 49.6%.

TABLE II

Ratio of Copper / Zinc in Citric Acid

(Values in Bracket represent inhibitor concentration)

Duration : 5 days

Inhibitor	0.2 *N*	0.5 *N*	1.0 *N*
Nil	1.72—	1.42—	1.40—
Pyrogallico Acid	0.74 (1.0 %)	0.80 (2.0 %)	0.44 (2.0%)
Tannic Acid	1.56 (1.0 %)	0.51 (1.0 %)	0.80 (2.0°/。)
Gelatine	0.19 (2.0 %)	0.15 (2.0 %)	1.45 (2.0 %)
Gum Arabic (Acacia)	1.96 (2.0 %)	1.53 (2.0 %)	0.54 (2.0 %)
Dextrin	1.07 (1.0 %)	1.50 (2.0 %)	0.81 (2.0 %)
Agar-Agar	0.60 (1.0 %)	0.51 (2.0 %)	2.40 (2.0 %)

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Amounts of copper and zinc going in solution are expressed as ratios of copper/zinc in Table 2.

Brass dissolves as a whole unit in 0.2 N citric acid solution, but there is a slight dezincification of brass at higher concentrations of acid studied.

Pyrogallol and tannin enhance the dezincification of brass in citric acid. Gelatine strongly accelerates the dezincification in 0.2N and 0.5 N solutions of citric acid. In 1.0 N citric acid, however, gelatine does not influence the proportions of constituents dissolving in citric acid solutions. In 0.2N citric acid solution, acacia slightly increases the attack on copper. In 0.5N citric acid solution acacia decreases dezincification to a small extent. In 1.0 N citric acid solution, however, acacia enhances dezincification of brass. Dextrin induces dezincification in 0.2N and 1.0N citric acid Agar-agar accelerates dezincification in 0.2N and 0.5N citric acid but facilitates the attack on copper in 1.0N citric acid.

A plot of log inhibitor concentration against log retardation of corrosion shows that the adsorption law is obeyed the following inhibitor concentration range :

	0.1N	0.5N	1.0
Agar-agar	0.5% - 2.0%	0.5% - 2.0%	0.5% - 2.0%
Dextrin	0.5% - 2.0%	0.2% - 2.0%	0.2% - 1.0%
Gelatine	0.5% - 2.0%	—	0.2% - 1.0%
Acacia (Gum arabic)	0.5% - 2.0%	—	0.2% - 1.0%

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INHIBITION OF THE CORROSION OF 63/37 BRASS IN NITRIC ACID

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Abstract

Sodium sulphite and sodium bisulphite have been investigated as inhibitors for the corrosion of 63/37 brass in nitric acid solutions. In 2.0 N nitric acid the concentrations of sodium sulphite and bisulphite required for the inhibiting the brass completely are 0.1% and 0.2% respectively, whereas the corresponding values in 3.0 N nitric acid are 1.0% and 2.0% respectively.

* * *

Potassium dihydrogen phosphate[1], stannous chloride[1], naphthenic acid[1], oleic acid[1], cobalt linolate1[1] and furfuraldehyde[2] have been investigated as inhibitors for the corrosion of brass in nitric acid solutions. The present study has been undertaken to investigate sodium sulphite and bisulphite as corrosion inhibitors for 63/37 brass in nitric acid.

Observations

The dissolution of 63/37 brass in nitric acid increases with time as well as with an increase in concentration of nitric acid.

The loss in weight of 63/37 brass in the presence and absence of inhibitors in 2.0N and 3.0N solutions of nitric acid is given in Tables 1 and 2 respectively.

Sodium sulphite is effective in 2.0N nitric acid and effective inhibition is obtained at lower concentrations of sodium sulphite as compared to that in 3.0N nitric acid. Tuhs, in 2.0N nitric acid, 0.1% concentration of sodium sulphite affords nearly complete protection to 63/37 brass, whereas in 3.0N nitric acid, the effective concentration is 2.0%. It should be noted that 1.0% concentration of sodium sulphite is effective in protecting brass in 3.0N nitric acid only upto 15 minutes; after that there is a remarkable fall in its efficiency. In 2.0N nitric acid at 0.01% concentration of the inhibitor, initially, there is an acceleration of corrosion of brass.

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TABLE 1

Inhibitor concentration	15 *mins.*	30 *mins.*	60 *mins.*	90 *mins.*	120 *mins.*
Nil	153.8	317.0	685.7	1116.0	1578.0
Sodium Sulphite					
0.1 %	0.0 (100.0)	0.28 (99.9)	0.56 (99.9)	0.84 (99.9)	1.12 (99.9)
0.2 %	0.0 (100.0)	0.0 (100.0)	0.56 (99.9)	0.84 (99.9)	1.12 (99.9)
Sodium Bisulphite					
0.1 %	0.0 (100.0)	0.0 (100.0)	140.0 (79.6)	308.0 (77.8)	476.0 (69.8)
0.2 %	0.0 (100.0)	0.0 (100.0)	0.0 (100.0)	0.0 (100.0)	0.0 (100.0)

TABLE 2

Inhibitor concentration	15 *mins.*	30 *mins.*	60 *mins.*	90 *mins.*	120 *mins.*
Nil	243.2	1039.0	1693.0	5097.0	10670.0
Sodium Sulphite					
1.0 %	0.0 (100.0)	0.0 (100.0)	0.56 (99.9)	1568.0 (69.2)	4480.0 (58.0)
2.0 %	0.0 (100.0)	0.0 (100.0)	0.0 (100.0)	0.0 (100.0)	1.7 (99.9)
Sodium Bisulphite					
1.0 %	0.0 (100.0)	0.0 (100.0)	197.0 (88.3)	840.0 (81.7)	2100.0 (80.3)
2.0 %	0.0 (100.0)	0.0 (100.0)	0.0 (100.0)	0.56 (99.9)	126.0 (98.8)

Sodium Bisuplhite

At 0.2% concentration of sodium bisulphite, the corrosion of 63/37 brass in 2.0N nitric acid is arrested completely. Even at 0.1% concentration, the inhibitor shows immediate effect, however, after 30 minutes, there is a notable fall in its efficiency. In this case also, with the increase in acid concentration, effective inhibition is obtained at higher inhibitor concentrations. Thus, in 3.0N nitric acid, 2.0% sodium bisulphite is needed to afford adequate protection to brass, addition of sodium bisulphite initially accelerates the corrosion of brass in 2.0N nitric acid.

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Amounts of copper and zinc going in solution are expressed as Cu/Zn ratios in Table 3.

TABLE III

	5 *mins*	10 *mins*	15 *mins*	30 *mins*	60 *mins*	90 *mins*	120 *mins*
Blank							
2.0 *N*	—	—	2.13	2.20	2.30	1.95	2.06
3.0 *N*	1.76	1.83	1.89	1.47	1.70	—	—
Sodium Sulphite							
2.0 *N* (0.09%)	—	—	1.60	1.50	1.49	1.40	—
3.0 *N* (0.5%)	—	1.47	1.43	1.25	1.1	—	—
Sodium Bisulphite							
2.0 *N* (0.05%)	—	—	1.49	1.44	1.40	1.35	—
3.0 *N* (0.5%)	—	1.54	1.60	1.48	1.38	—	—

From this table, it can be seen that in 2.0N nitric acid there is a selective dissolution of copper. In 3.0N nitric acid also, initially there is preferential dissolution of copper, whereas for 30 minutes duration there is a slight attack on zinc. For 60 minutes duration, however, 63/37 brass dissolves as a whole unit. In the presence of sodium sulphite and bisulphite, the attack on zinc phase becomes more evident.

Captions

Table 1 : Effect of inhibitor concentration and time on efficiency of sodium sulphite and sodium bisulphite in 2.0N nitric acid.

Table 2 : Effect of inhibitor concentration and time on efficiency of sodium sulphite and sodium bisulphite in 3.0N nitric acid.

Table 3 : Ratios of Copper / *Zinc* in 2.0N and 3.0N nitric acid in the presence and absence of inhibitors.

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INHIBITION OF THE CORROSION OF 63/37 BRASS IN POTASSIUM PERSULPHATE SOLUTIONS

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Potassium persulphate solutions are highly corrosive to metals and alloys, the rate of dissolution being of the order of $72 g/M^2/day$.[1]

Sheppard[2] observed that if a strip of brass is dropped in potassium persulphate solution, it is blackened immediately and completely. Potassium persulphate can be used to remove oxide layers but as it is highly corrosive, suitable inhibitors are needed. So far no inhibitors have been suggested for brass in potassium persulphate solutions.

Experimental

63/37 Brass supplied by Messrs Kamani Metals and alloys, Bombay was used in the experiments carried out by us. The preparation of specimens (6 cm. x 3 cm. x 28 S.W.G.), corrosion tests and cleaning of specimens after corrosion were carried out as described in our earlier publications[3,4]; all the experiments were carried out at 35°±0.1°C.

Observations : Loss in Weight Data

0.2M Potassium persulphate solution is highly corrosive to 63/37 brass, the loss in weight of the metal ranging from 171.8 to 3090 mg/dm² for five minutes to ninety minutes durations.

The loss in weight of 63/37 brass in presence of the inhibitors investigated is given in Table 1.

Ethyl methyl ketone is not an effective inhibitor as the efficiency decreases considerably with time. The corrosion of brass during five minutes is effectively retarded to an extent of about 96% in the presence of 26.10 ml/l or 34.80 ml/l of ethyl methyl ketone and for thirty minutes period the efficiency falls to about 20% and 33% respectively.

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TABLE I

63/37 Brass Potassium Persulphate

Inhibitor Concentration (ml/litre)	Weight loss of specimen (mg/dm2) and % inhibition for an immersion period of : (Values in the bracket represent percentage inhibition)				
	5 min.	15 min.	30 min.	60 min.	90 min.
Nil	171.8	559.7	1153.0	2250.0	3090.0
Ethyl methyl Ketone :					
4.35 ml/1	162.6 (5.3.)	523.3 (6.1)	1160.0 (-0.6)	2192.0 (7.0)	3063.0 (0.9)
34.80 ml/1	5.2 (96.4)	112.5 (79.9)	774.3 (+32.9)	1530.0 (32.0)	2516.0 (18.6)
Acetophenone					
4.35 ml/1	0.8 (99.6)	2.5 (99.6)	2.5 (99.9)	2.8 (99.9)	2.8 (99.9)
8.70 ml/1 (Sat.)	3.6 (97.9)	8.9 (98.4)	17.7 (98.5)	45.2 (98.0)	51.2 (98.4)

Acetophenone is highly effective as an inhibitor. Even in the presence of as small a concentration as 0.43 ml/1 of acetophenone, the corrosion of brass during ninety minutes period is retarded to an extent of 99.7%. At 4.35 ml/1 concentration of acetophenone, the corrosion of brass is retarded to an extent of 99.6% during the periods studied. With further increase in inhibitor concentration, the efficiency falls.

The corrosive attack of potassium persulphate solution is mainly directed towards the zinc constituent of the alloy; the values of copper/ zinc ratios ranging from 0.28 to 0.34 for all the durations studied.

In the presence of ethyl methyl ketone, there is severe decuprification, acetophenone, however, gives very interesting results. Initially, in the presence there is a high decuprification, which subsequently decreases, though the tendency is perceptible in fifteen minutes duration. For thirty minutes duration, 63/37 brass dissolves as a whole unit in presence of acetophenone, but for longer durations a slight tendency for dezincification is noted.

The change in potential of 63/37 brass with time in 0.2M potassium persulphate in the absence and presence of inhibitors is given in Fig. 1.

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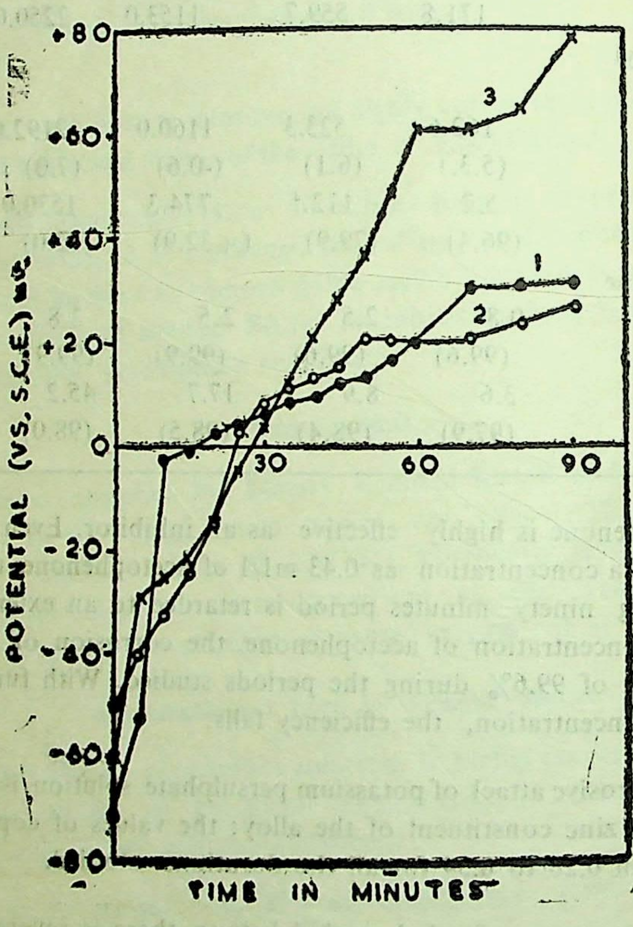
Initially, the potential in uninhibited 0.2M $K_2S_2O_8$ is negative and becomes positive with time. The steady state potential is +30 mv. The effect of current density on the cathode and anode potentials in 0.2M potassium persulphate in the absence and presence of acetophenone is given in Figs. 2 and 3 respectively. In 0.2M $K_2S_2O_8$ and upto a current density of 6.496×10^{-3} amp/cm² both the cathode and anode are not considerably polarised, however, beyond 6.496×10^{-3} amp/cm² the cathode is considerably polarised as compared to the anode.



The efficiency of acetophenone is less in the presence of 8.70 ml/l acetophenone as compared to that in the presence of 2.17 ml/l acetophenone. Between ten to twenty minutes, the potential values in the presence of 2.17 ml/l and 8.70 ml/l acetophenone are distinctly more negative than those in 0.2M potassium persulphate solutions. The potential values in the presence of 8.70 ml/l acetophenone are distinctly more positive between forty to ninety minutes than those in the presence of 2.17 ml/l acetophenone or in 0.2M potassium persulphate. The effect of current density on the cathode and anode potentials of 63/37 brass in 0.2M potassium persulphate

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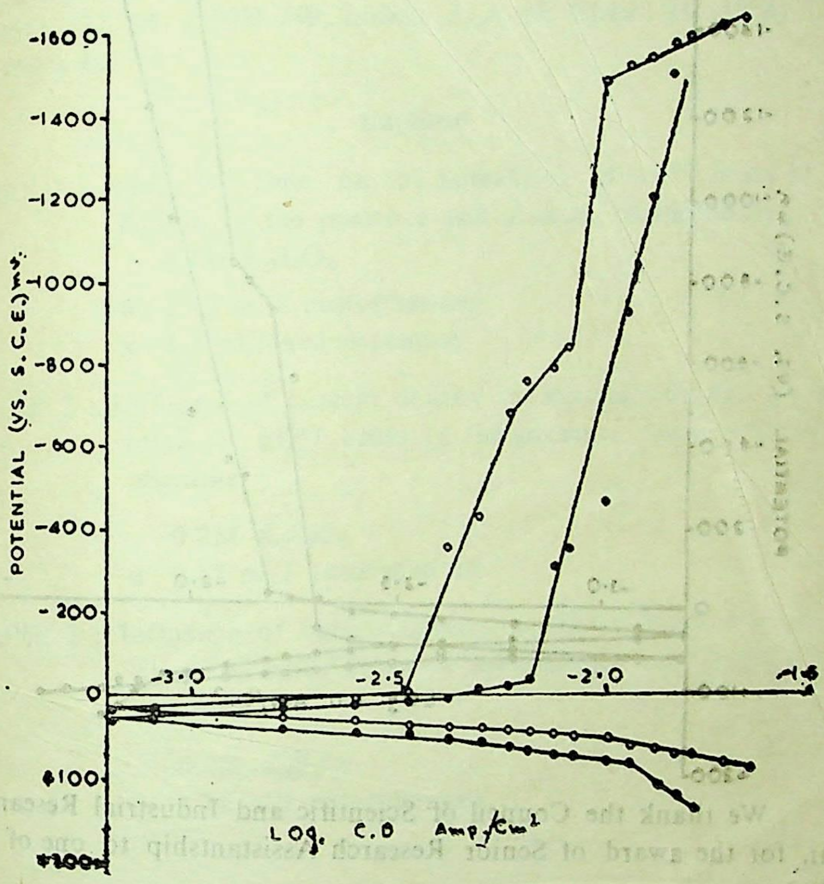
in the presence of 2.17 ml/1 and 8.70 ml/1 acetophenone is given in Figs. 2-3. In the presence of 2.17 ml/1 acetophenone, there is a considerable



cathode polarisation. Beyond the current density 6.496×10^{-8} amp/cm², the shift in the potential in the presence of 2.17 ml/1 acetophenone during anode polarisation is less than that in 0.2M potassium persulphate. In the presence of 8.70 ml/1 acetophenone, upto the current density $4.872 + 10^{-8}$ amp/cm², the cathode is depolarised. With further increase in the current density, however, there is a considerable cathode polarisation. If we compare the cathode polarisation in the presence of 2.17 ml/1 and 8.70 ml/1 acetophenone, it will be observed that the shift in the cathode potential is to a greater extent in the presence of 2.17 ml/1 acetophenone than that in the presence of 8.70 ml/1 acetophenone. This is in accordance with the decreased efficiency of acetophenone at 8.70 ml/1 concentration. The shift in potential during anode polarisation also decreases with the concentration of acetophenone, Acetophenone appears to be predominantly a cathodic inhibitor.

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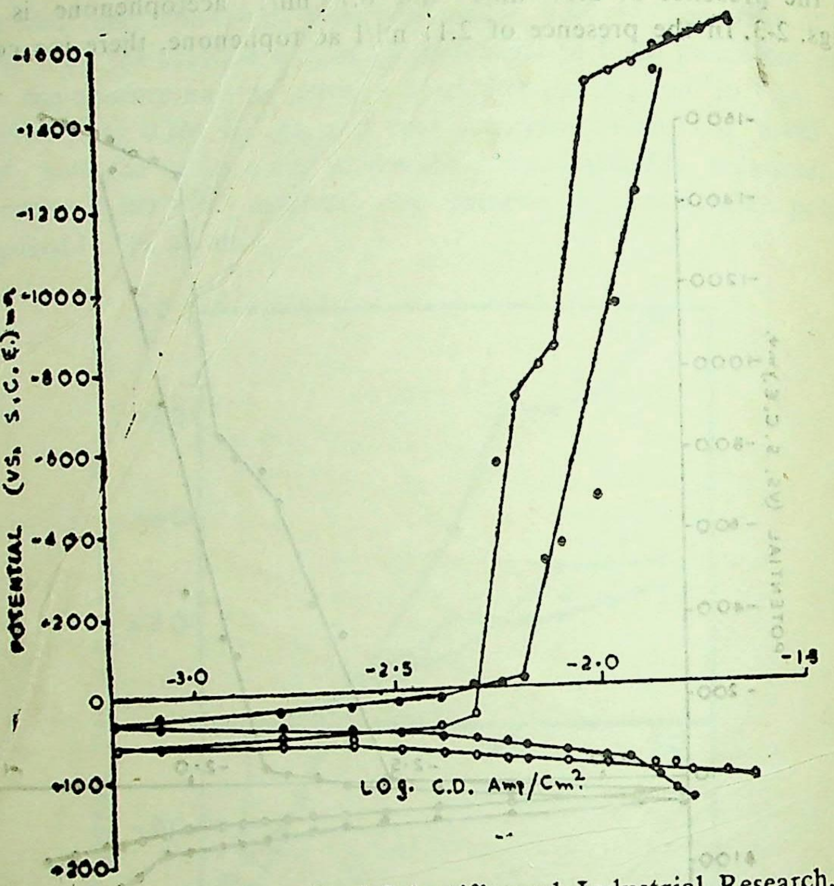

We thank the Council of Scientific and Industrial Research, New Delhi, for the award of Senior Research Assistantship to one of us (Y.C Shah).

TABLE 2

Inhibitor	Ratio of copper/zinc in 0.2M potassium persulphate : (Values in the bracket represent inhibitor concentration - ml/litre				
	5 min.	15 min.	30 min.	60 min.	90 min
Nil	0.28	0.31	0.33	0.34	0.34
Ethyl Methyl Ketone	3.00 (34.80 ml/1)	3.25 (34.80 ml/1)	– –	– –	– –
Aceto-phenone	5.50 (8.70ml/1)	2.55 (8.70 ml/1)	1.66 (8.70 ml/1)	0.72 (8.70 ml/1)	1.07 (8.70ml/1)

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Captions

FIGURE 1 : Effect of time on the potentioal of 63/37 brass in 0.2M. $K_2S_2O_8$ in the presence and absence of inhibitors.

. 0.2M $K_2S_2O_8$

o 2.17 ml/1 acetophenone

x 8.7 ml/1 acetophenone

FIGURE 2 : Influence of current density on the cathode and anode potentials of 63/37 brass in the presence and absence of acetophenone.

. 0.2M $K_2S_2O_8$

o 2.17 ml/1 acetophenone.

FIGURE 3 : Influence of current density on the cathode and anode potentials of 63/37 brass in the presence and absence of acetophenone.

. 0.2M $K_2S_2O_8$

o 8.70 ml/1 acetophenone.

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METHYLAMINES AS CORROSION INHIBITORS FOR ALUMINIUM-2S IN HYDROCHLORIC ACID

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Abstract

Methylamine, dimethylamine and trimethylamine have been investigated as corrosion inhibitors for aluminium-2S in hydrochloric acid solutions. Weightloss data at 35°C and higher temperature, indicate that dimethylamine is the most effective inhibitor. This is confirmed by cathodic protection studies in 2.0 N HCl. The efficiency of methylamines in 1.0 N HCl increases with temperature. In 1.0 N hydrochloric acid, methylamines are predominantly anodic inhibitors whereas in 2.0 N HCl, they exert predominant influence on the local cathodes.

Methyl amines have been used as inhibitors for the corrosion of tins in canned foods by Jakobsen[1] and for the corrosion of iron in acidic media, by Mann[2] and Antonucci[3]. Geller[4] made a preliminary study of retardation of corrosion of aluminium in 1.4N hydrochloric acid by aliphatic amines. The present paper describes the retardation of corrosion of aluminium-2S in hydrochloric acid, by methylamines.

Aluminium alloy Indal-2S manufactured by Messers Indian Aluminium Company was selected for the study, in view of its widespread use. It has been specified as follows by the manufactures :

Indal 2S - half hard, aluminium 99%
Fe – 0.4%, Si - 0.3%, Mn and Mg – 0.1% Cu, Ca, Ti – traces.

The preparation of specimens and corrosion studies were carried out as described in our previous publication[5].

Observations :

The corrosion of aluminium-2S in hydrochloric acid increases with time as well as with acid concentration. The effect of inhibitor concentration on inhibitor efficiency is shown in Table I, while the effect of time is shown

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in Table II. In the presence of 2.17 ml/1 methylamine, there is a slight acceleration of corrosion of aluminium-2S in 1.0N hydrochloric acid for 2 hours duration. However, its performance improves with increased inhibitor concentration. In 2.0N hydrochloric acid, methyl amine affords a better protection to aluminium-2S, which is evident from the absence of acceleration of corrosion in the presence of lower inhibitor concentration, as well as by the fact that the retardation of corrosion by 43.5 ml/1 methylamine in 1.0 N and 2.0 N solutions of hydrochloric acid is 53.9% and 75.8% respectively.

Another noteworthy point is that for reducing corrosion by about 50%, 43.5 ml/1 methylamine is needed in 1.0 hydrochloric acid, whereas the corresponding inhibitor concentration in 2.0 N hydrochloric acid is only 17.4 ml/1. The initial efficiency of methylamine is greater than the corresponding values for subsequent durations.

TABLE 1

1.0 N HYDROCHLORIC ACID *Duration* : **120** *Minutes*

Inhibitor Concetration	*Methylamine*		*Dimethylamine*		*Trimethylamine*	
	Loss mg/dm²	*% Efficiency*	*Loss mg/dm³*	*% Efficiency*	*Loss mg/dm³*	*% Efficiency*
Nil	151.2	—	151.2	—	151.2	—
2.17 ml/1	166.3	−10.0	113.4	25.0	—	—
4.35 ml/1	146.3	+ 3.2	80.7	46.6	172.8	−14.3
8.70 ml/1	133.6	+11.6	68.6	54.6	148.5	+ 1.8
17.40 ml/1	120.6	+20.5	63.7	57.8	130.4	+13.8
26.10 ml/1	95.8	+36.6	59.9	60.3	115.3	+23.8
34.80 ml/1	86.4	+42.8	59.4	60.7	106.1	+29.8
43.50 ml/1	69.6	+53.9	58.0	61.6	89.1	+41.1

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2.0 N HYDROCHLORIC ACID

Duration : 30 Minutes

Inhibitor Concentration	Methylamine Loss mg/dm²	Methylamine % Efficiency	Dimethylamine Loss mg/dm²	Dimethylamine % Efficiency	Trimethylamine Loss mg/dm²	Trimethylamine % Efficiency
Nil	3105.0	–	3105.0	–	3105.0	–
2.17 ml/l	2790.0	10.1				
4.35 ml/l	2603.0	16.2	977.0	68.6	2174.0	30.0
8.70 ml/l	2028.0	34.7	870.0	72.0	1712.0	44.8
17.40 ml/l	1478.0	52.4	709.0	77.2	1397.0	55.0
26.10 ml/l	1194.0	61.5	639.0	79.4	1236.0	60.2
34.80 ml/l	995.0	69.4	597.0	80.8	1010.0	67.6
43.50 ml/l	750.0	75.8	549.0	82.3	875.0	71.8

Of the three methylamines, dimethylamine is the most efficient inhibitor. In general, its efficiency decreases with time in 1.0N hydrochloric acid but improves with time in 3.0 N hydrochloric acid. For the periods of study, the efficiency of dimethylamine in 2.0 N hydrochloric acid ranges from 82-87%, the corresponding value for 4.0 N HCl being 84–94%. For 10 minutes duration, the inhibitor efficiency remains nearly constant with increase in acid concentration.

TABLE II

It is observed that the first member of the homologous series of aliphatic tertiary amines is not a very effective inhibitor for the corrosion of aluminium-2S in hydrochloric acid. In 1.0N hydrochloric acid, at 43.5 ml/l concentration of trimethylamine, the corrosion is accelerated, however, its performance improves with increase in acid concentration. The effect of trimethylamine is immediate in 1.0 and 2.0N, and 4.0N hydrochloric acid but in general, the efficiency decreases with time. In 3.0N hydrochloric acid the efficiency improves with time. For 10 minutes duration, the inhibitor efficiency remains practically constant with increase in acid concentration.

Plots of logarithm of aluminium surface covered by the inhibitor (log θ) against logarithm of inhibitor concentration show that in 1.0N and 2.0N solutions of hydrochloric acid, Freundlich adsorption isotherm is obeyed in the concentration range 8.7 – 43.5 ml/1. The influence of current density on the cathode and anode potentials of aluminium 2S in uninhibited 1.0N hydrochloric acid and in the presence of methylamine, dimethylamine, trimethylamine is given in figures 1, 2, 3 and 4 respectively. From

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TABLE II

	1 *min.*	2 *min.*	5*min.*	10 *min.*	15 *min.*	30 *min.*	60 *min.*	120 *min.*	180*min.*
1.0 N HCl									
Nil	–	–	–	33.2 (–)	–	113.4 (–)	127.5 (–)	151.2 (–)	172.8 (–)
Methylamine (43.5 ml/1)	–	–	–	6.5 (80.5)	–	34.5 (69.5)	54.0 (57.6)	69.6 (53.9)	90.7 (47.5)
Dimethylamine (43.5 ml/1)	–	–	–	5.7 (82.9)	–	29.5 (73.8)	58.9 (53.8)	63.7 (57.8)	86.0 (50.0)
Trimethylamine (43.5 ml/1)	–	–	–	8.1 (75.6)	– (60.2)	45.1 (60.2)	71.8 (43.6)	43.6 (89.1)	98.1 (43.3)
2.0 N HCl									
Nil	–	–	58.9 (–)	568.5 (–)	88.4 (–)	3105 (–)	–	–	–
Methylanine (43.5 ml/1)	–	–	11.4 (80.7)	179.3 (68.4)	374.0 (58.0)	750.0 (75.8)	2004 (–)	–	–
Dimethylamine (43.5 ml/1)	–	–	10.3 (82.1)	94.5 (83.4)	150.1 (77.0)	549.2 (82.3)	1139 (–)	–	–
Trimethylamine (43.5 ml/1)	–	–	15.7 (73.4)	136.4 (76.0)	327.2 (63.2)	875.4 (71.8)	1602 (–)	–	–

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Table II (contd.)

	1 *min.*	2 *min.*	4 *min.*	10 *min.*	15 *min.*	30 *min.*	60 *min.*	120 *min.*	180 *min.*
3.0 N HCl									
Nil	–	–	343.0	4384	–	–	–	–	–
			(–)	(–)					
Methyamine	–	–	122.0	1124	1228	5750	–	–	–
(43.5 ml/1)			(64.4)	(74.3)	(–)	(–)			
Dimethylamine	–	–	117.4	497.3	1108	3658	–	–	–
(43.5 ml/1)			(65.7)	(86.6)	(–)	(–)			
Trimethylamine	–	–	129.9	927.9	3099	6398	–	–	–
(43.5 ml/1)			(62.1)	(78.8)	(–)	(–)			
4.0 N HCl									
Nil	71.0	297.0	4915	–	–	–	–	–	–
	(–)	(–)	(–)						
Methylamine	10.5	79.4	789.5	3087	–	–	–	–	–
(43.5 ml/1)	(85.1)	(73.2)	(83.9)	(–)					
Dimethylamine	3.8	47.2	443.0	1563	–	–	–	–	–
(43.5 ml/1)	(94.3)	(84.1)	(90.9)	(–)					
Trimethylamine	14.6	78.9	1460	5501	–	–	–	–	–
(43.5 ml/1)	(79.4)	(73.4)	(70.3)	(–)					

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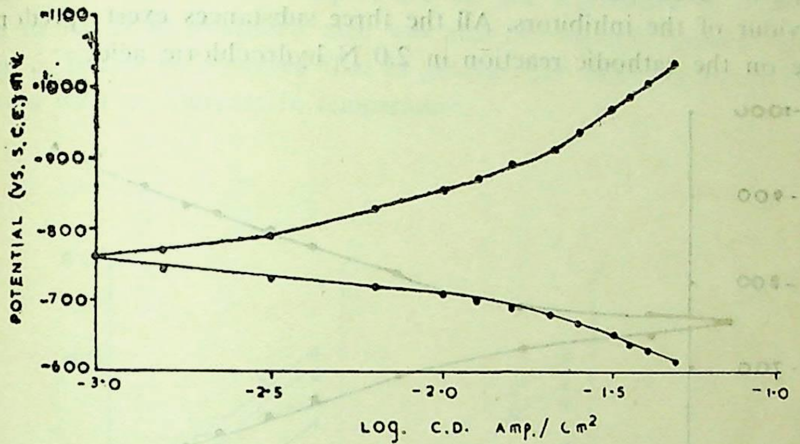
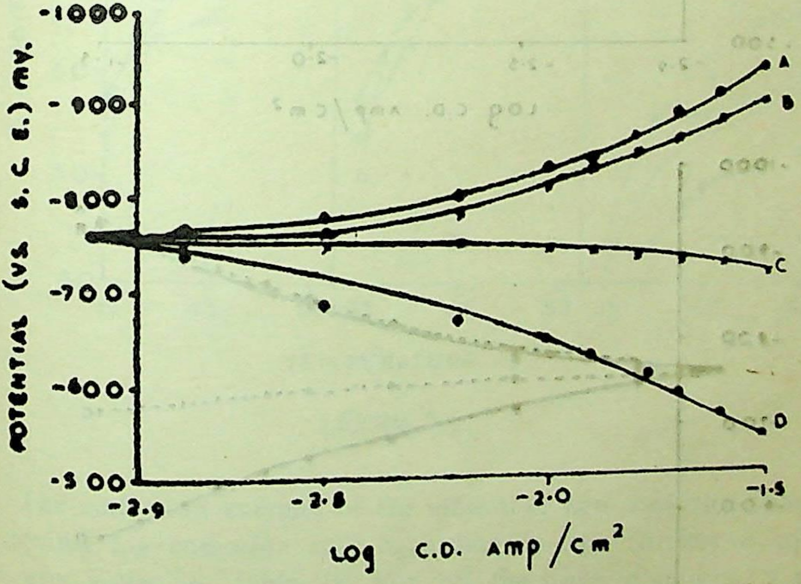
Fig. 2, it can be seen that at 2.17 ml/1 concentration of methylamine the shifts in potential in the anode and cathode polarisation are less than those in its absence. This explains the acceleration of corrosion observed in the presence of 2.17 ml/1. methylamine. At higher inhibitor concentration, there is a considerable increase in the polarisation of the anode, while the cathode polarisation values are less as compared to those in 1.0 N hydrochloric acid. Thus in 1.0 N hydrochloric acid, methylamine inhibits the corrosion of aluminium 2S by increasing the anode polarisation.





(Figure 1) (Figure 2)

From the Fig. 3, it can be seen that there is a significant increase in anode polarisation in the presence of dimethylamine indicating its effect

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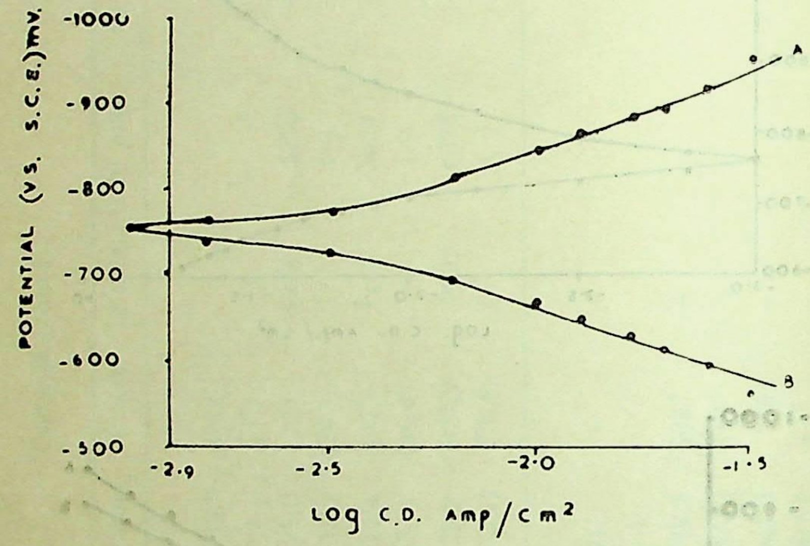
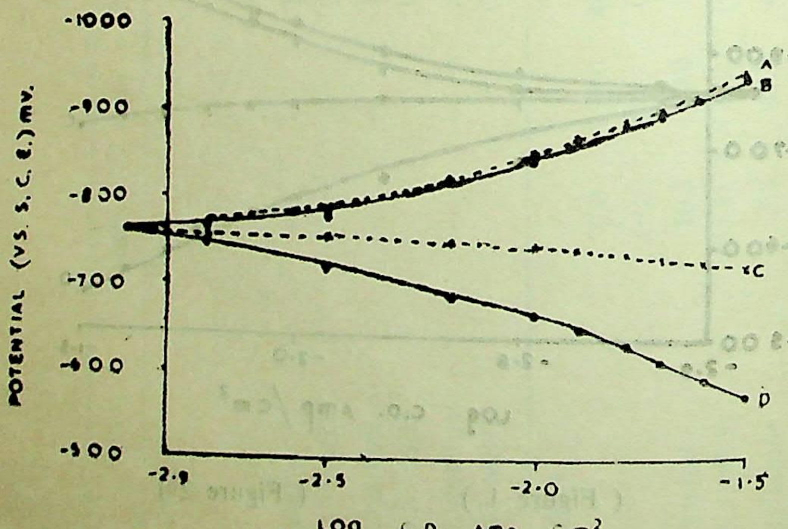
on the local anodic areas. Upto the current density 1.624×10^{-2} amp/cm^2 the cathode polarisation is less than that in uninhibited 1.0 N hydrochloric acid, but with subsequent increase in current density, the cathode polarisation sets in. Addition of 43.5 ml/l trimethylamine to 1.0 N HCl induces an increase in anode polarisation and a decrease in cathode polarisation (Fig. 4). However, at 4.35 ml/l concentration of trimethylamine, both anode and cathode polarisations are decreased, explaining the acceleration of corrosion in the presence of 4.35 ml/l trimerthylamine. However, it is interesting to note that in 2.0 N hydrochloric acid, there is a reversal of behaviour of the inhibitors. All the three substances exert predominant influence on the cathodic reaction in 2.0 N hydrochloric acid.





(Figure 3) (Figure 4)

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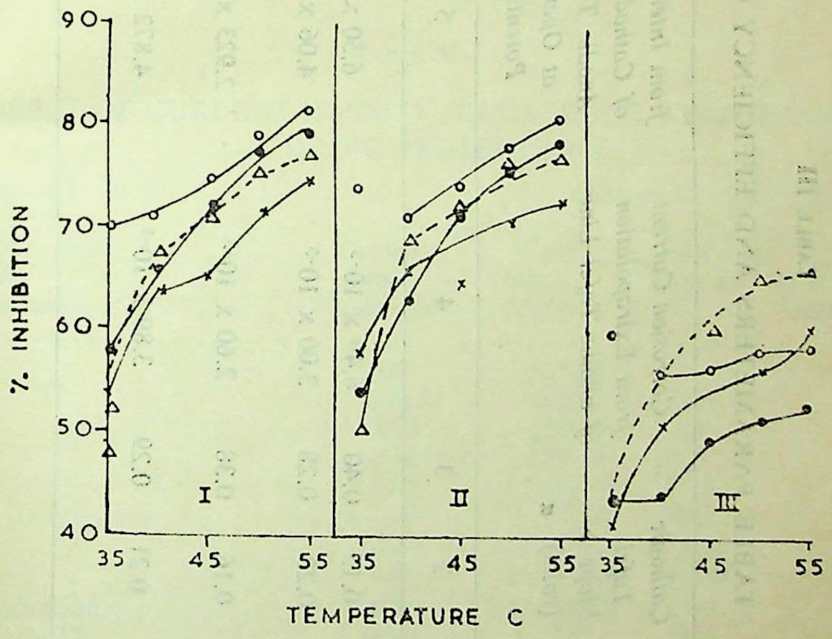
The values of Tafel parameters and the efficiencies of the inhibitor in 1.0 N HCl, evaluated from (1) extrapolation of anode tafel line to the open circuit potential, and (2) from the intersection of cathodic and anodic tafel lines at the open circuit potential are shown in Table III. It has been found that with all the inhibitors, a good correlation is observed between efficiency of inhibitors calculated from extrapolation of anodic tafel line to open circuit potential with those evaluated from loss in weight method. This also indicates that the inhibitors are predominantly anodic in action. The influence of temperature on the retardation of corrosion of Al-2S in 1.0 N hydrochloric acid was also investigated. Results are shown in Fig. 5. It can be observed that in general, the efficiency of methylamines increases with an increase in temperature.



(*Figure* 5)

The activation energies of the inhibitors were evaluated from Plots of 1/T against log corrosion rates according to the Arrhenius equation. Results are given in Table IV. For all the three inhibitors, it may be concluded that the values of activation energy are lower in the presence of inhibitors than those in its absence, indicating that the inhibitors become more effective as the temperature rises.

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TABLE III

TABLE PARAMETERS AND EFFICIENCY OF INHIBITORS

Inhibitor Concentrarion	*Cathodic Tafel Slope b (volts)*	*a*	*Corrosion Current from Extrapolation of anodic Tafel Line*	*from Intersection of Cathodic and Anodic Tafel Lines at Open Circuit Potential*	*Inhibitor from (4)*	*Efficiencty from (5)*	*from Weight Loss Date*
1	2	3	4	5	6	7	8
Nil	0.15	0.40	6.49 x 10^{-3}	6.50 x 10^{-3}			
Methylamine (43.5 ml/1)	0.22	0.28	3.00 x 10^{-3}	4.06 x 10^{-3}	53.8	37.8	57.80
Dimethylamine (43.5 ml/1)	0.16	0.38	2.60 x 10^{-3}	2.923 x 10^{-3}	60.0	55.0	57.74
Trimethylamine (43.5 ml/1)	0.21	0.29	3.89 x 10^{-3}	4.872 x 10^{-3}	41.6	25.0	41.60

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The activation energies of the inhibited reactions at high coverages can be either larger or a smaller than the uninhibited reaction. Machu[6] had reported that for powerful inhibitors, the activation energy is lower for

TABLE IV

ACTIVATION ENERGIES IN THE PRESENCE AND ABSENCE OF INHIBITIORS

(*In K-Cal/Mole*)

Inhibitor		30 *Minutes*	60 *Minutes*	120 *Minutes*	180 *Minutes*
Nil		15.6	14.7	13.0	13.0
Methylamine	(43.5 ml/1)	9.67	8.28	6.91	5.53
Dimethylamine	(43.5 ml/1)	8.75	9.21	7.83	7.37
Trimethylamine	(43.5 ml/1)	13.48	11.52	8.75	7.37

TABLE V

EFFECT OF CURRENT DENSITY ON CATHODE WEIGHT LOSS (CATHODIC PROTECTION)

2.0 N HCl *Aluminium*-2S 30 *Minutes*

Inhibitor and inhibitor concentration	*Current density amp/cm²*	*Weight loss Mg/dm²*	*Protection current*	*% due to current inhibitor*
nil	0.0	3125.0	–	–
	0.325	2829.0	9.5	–
	0.65	2566.0	17.9	–
	1.14	1971.0	36.8	–
	1.95	1054.0	66.3	–
	2.60	282.3	90.9	–
	2.76	176.9	9h.3	–
	2.84	0.0	100.0	–
Methylamine (43.5 ml/1)	0.0	749.8	–	76.9
	0.81	339.1	54.8	89.6
	0.89	27.6	96.4	99.1
	0.97	0.0	0.0	100.0
Dimethylamine (43.5 ml/1)	0.0	639.5	–	80.3
	0.65	495.0	22.6	84.7
	0.81	74.7	88.3	97.7
	0.89	0.0	100.0	100.0
Trimethylamine (43.5 ml/1)	0.0	1007.0	–	69.0
	0.81	555.0	44.8	82.9
	0.97	215.9	78.5	93.3
	1.14	0.0	100.0	100.0

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inhibited than for uninhibited reaction. This type of behaviour has been explained by Putilova[7] as due to an increase in the surface area of the metal covered by inhibitor molecules as the temperature rises. However, Riggs[8] suggested that at high coverages the extent of adsorption is no longer rate determining.

Studies of cathodic protection to aluminium-2S in 2.0 N hydrochloric acid indicate that addition of inhibitors considerably lowers the protective current (Table V).

Results obtained under external anodic current show that the difference effect is negative for Aluminium-2S in 2.0 N hydrochloric acid whereas in the presence of the inhibitors, the difference effect becomes positive. The values of difference effect coefficient were evaluated according to the equation,

$$KDE = \frac{\Delta icorr}{\Delta ip\sigma l}$$

The values of KDE in uninhibited hydrochloric acid and in the presence of 43.5 ml/l methylamine, dimethylamine and trimethylamine are −0.37 +0.55 +0. 61, and +0.61 respectively. The superior inhibitive action of dimethylamine is brought about by the studies of cathodic protection also. In the presence of 43.5 ml/l concentration of methylamine, dimethylamine and trimethylamine, the current needed to afford complete protection to Aluminium-2S is 0.97, 0.89 and 1.1 amp/dm^2 respectively.

We thank the Ministry of Education for the award of a Research Training Fellowship to one of us (Y. B. Desai).

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CAPTIONS

Fig. 1

Effect of varying current density on the cathcde and anode potentials of aluminium 2S in 1.0 N hydrochloric acid.

Fig. 2

Effect of varying current density on the cathode and anode potentials of aluminium 2S in 1.0 N hydrochloric acid in the presence of methylamine.

AD—43.5 ml/l methylamine
BC – 2.17 ml/l methylamine

Fig. 3

Effect of varying current density on the cathode and anode potentials of aluminium 2S in 1.0 N hydrochloric acid in the presence of 43.5 ml/l dimethylamine.

Fig. 4

Effect of varying current density on the cathode and anode potentials of aluminium 2S in 1.0 N hydrochloric acid in the presence of trimethylamine.

AC—43.5 ml/l trimethylamine
BD—4.35 ml/l trimethylamine.

Fig. 5

Influence of temperature on the performance of inhibitors in 1.0 N HCl.

I Methylamine, II Dimethylamine, III Trimethylamine.

0———0 30 minutes
°———° 60 minutes
△———△ 120 minutes
x———x 180 minutes.

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ADAPTATIONS FOR FOOD GETTING IN GREEN BEE-EATER

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Correlation of the form and function is so universal among animals and often so obvious, that it has been known since the beginning of the biological science. The bird, the highly specialized animal, provides excellent material for the study of structural adaptation. Specialization in feeding and locomotion, are frequently correlated with striking modifications in body form.

The correlation between the adaptive modifications in structure and function has been established in class Aves by Burt (1930) on the relationship between the feeding habits and head morphology of the woodpecker, By Moller (1930–'31) on the functional anatomy of the bill and tongue in the nectar eating birds. Engels (1940) correlated structural adaptations with locomotor and feeding behaviour in thrushes. Richardson (1942) worked on the adaptive modifications for treetrunk forging in birds. Beecher (1950, 1951*a*, 1951*b*) correlated feeding habits with the anatomy of the skull in American orioles, honey creepers and American black-birds. Correlation of the jaw architecture and feeding behaviour of Black-skimmer was studied by Zusi (1962) and of Waterfowl by Goodman and Fisher (1962). Considerable amount of such work has come out from this laboratory on Picarian (Rawal, 1966) and Passarine (Malhotra, 1967) birds.

The present study is basically an anatomical study. The study pertains to interrelationships between bones, muscles, kinds of food items and behaviour in securing food. The purpose is to determine the adaptive significance of any variations and to attempt to explain how a particular structure or combination of structures subserved a certain function.

Material and Methods

The birds were shot with air-rifle, their heads were removed from the body and were immediately preserved in the field in 10% formalin. From the remaining part of the body the crop and stomach were removed. The stomach was slightly punctured and was preserved in 10% formalin. The

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crop and stomach were dissected thereafter with least possible delay in the laboratory, for the study of their food content with the aid of dissecting binocular microscope. Various specimens were collected from different areas at different time for stomach content study.

Some specimens which had least injury, were captured alive and nurtured for the study of the operation of the jaw muscles in live condition. For the study of the functional aspects of the muscles, the head region was carefully removed from such specimen and dissected in Ringer's solution (for birds). The function of the muscle was detected by stimulating it by 9 volts Eveready Energizer dry battery for about a second or two. The stimulation of the nerve innervating the particular muscle also proved equally effective in understanding the function of the muscle.

The skulls for the study were obtained by dissolving muscles in KOH. They were cleared in Glycerine-Hydrogen peroxide solution and dried in air-oven. For the study of kinesis the dried skull was boiled in a water for a minute or two and then put in glycerine.

The specimens were carefully dissected under the sterioscopic binocular dissecting microscope. The photographs of the dissected specimens were taken to note the exact position and nature of the muscles. Photographs of the skull and hyoid apparatus were also taken and the base drawings were prepared from the enlarged prints.

Dimensions of the bony elements of the skull which are closely associated with the feeding habits were studied. The method followed by Fisher (1944) and Goodman and Fisher (1962) was adopted during the study.

Feeding Behaviour and Food

This bird is seen after the sunrise on the lines (wires) of the electricity and telephone in the vicinity of the ponds and aquatic habitats. In the evening they are seen sheltering in flocks on the green tree such as Neem, Banyan, and Mango trees.

As it spots a flying insect it makes a rapid flight and captures the insect prey. After capturing the prey it generally batters the prey upon a branch of the tree or on wire and crushes it before swallowing. The bird is very quick on the wings and it rarely misses its swoop. However, if it fails to catch the food which is very rare case, the mandibles get twisted.

The stomachs examined consisted of insect wings, their terga and sterna, bees in crushed condition and broken wings and body parts of coleo-

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pterans. Mason and Lefroy (1912) and Dharmakumarsinhii (1955) state that the insects such as wasps, bees, butterflies and moths are the main food of the merops.

Bill Structure :

The bill is long. The upper mandible is long, narrow, slender and pointed anteriorly. But the lower arm is slightly shorter than the upper one. Their marginal lamellae are blade like. Internally, there is a well developed central ridge in the anterior region of the upper beak. This ridge extends upto the naso-pharyngeal slit. On either side of this ridge, there is a lateral ridge shorter in dimension. The inner surface is quite smooth. A few poorly developed projections are seen on either side of the naso-pharyngeal communication.

The lower beak is slightly grooved in the anterior region and possesses a distinct median ridge. Two folds arise laterally on either side of the median ridge. The tongue is situated in a depression formed by these folds.

The tongue is long, slightly pointed and triangular in shape. The surface of the tongue is smooth. Three blunt projections arise on either side towards the distal edge of the tongue.

OSTEOLOGY

In present study more emphasis is given on the dimensions of the skeletal elements of the skull. A brief account of the skull is given to understand the architecture of the skull.

The bony elements of the skull are thin. The cranium is shorter in length than that of the bill which is quite slender. The latter has broad triangular surface from above. The palate is desmognathous. The nasal bone arrangement is holorhinal type. The foramen magnum is situated backwards. The premaxillae are long being broad towards the base and pointed anteriorly. The squamosal has a well developed notch for the location of the adductor mandibulae externus superficialis mucsle. The quadratojugal bar is very thin and slender. It is slightly curved from outside. The dentary is slender and pointed anteriorly. The orbit is almost round.

The hyoid apparatus is very well developed and equal in length to that of cornua. The entoglossum consists of a single piece. Anteriorly it consists of a median process which gradually tapers to a point anteriorly. Distally it becomes broad and slightly bifid. The basihyal is short and rod shaped. Both its lateral surfaces are concave in outline. The urohyal is of the usual shapeni birds being broad anteriorly and becoming gradually narrow

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posteriory. The cornua has three elements, i.e., it has an additional element, viz. epibranchial besides the usual hypobranchial and ceratobranchial. The cornua retains its characteristic shape, its first bony element being concave from inside and next one being directed towards the tip. Both the ceratobranchial and hypobranchial are flat. The epibranchial gradually tapers to a point.

TABLE 1

Table 1 : The dimensions of the skeletal elements of the skull in Millimeters.

Skeletal elements	*Observed range*	*Mean*	*Standard Deviation*	*Coefficient Variation*
1. Length of the Cranium	15.5–17.0	16.16	0.44	2.77 %
2. Height of the cranium	9.0–10.0	9.40	0.44	4.76 %
3. Width of the skull	14.0–15.20	14.70	0.44	3.04 %
4. Width of the supra-orbital isthmus	6.5–7.0	6.5	—	—
5. Width of the posterior bill	9.0–9.3	9.30	—	—
6. Length of the bill	24.0–25.5	24.75	4.47	1.81 %
7. Length of the Prema-xillaries	14.5–17.0	15.50	0.77	4.99 %
8. Length of the pterygoid	5.0–5.5	5.14	—	—
9. Length of the palatine	13.0–14.5	13.5	0.63	4.68 %
10. Length of the quadrate	3.7–4.0	3.95	—	—
11. Length of mandible	33.5–35.5	34.25	0.89	2.61 %
12. Height of the mandible	2.5–2.6	2.53	0.63	2.9 %

The cranium of the bird which houses the brain is subjected to minimal amount of adaptive modifications (Goodman and Fisher, 1962). Therefore in the present investigation also the cranial length has been selected as basis of unity.

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Table 2 : Ratios of the skeletal elements in Millimeters.

Ratios	*Mean %*	*Standard deviation*	*Coefficient variation*
1. Cranial height : Cranial length	58.16	0.12	2.16
2. Skull width : Cranial length	91.51	0.03	4.02 %
3. Supraorbital isthmus : Cranial length	42.74	1.40	3.27 %
4. Bill length : Cranial length	153.10	1.00	0.64 %
5. Anterior premaxillary: Cranial length	95.71	0.48	0.50 %
6. Pterygoid length: Cranial length	31.76	0.15	0.47 %
7. Palatine length: Cranial length	83.49	—	—
8. Quadrate length : Cranial length	24.48	0.01	5.1 %
9. Mandibular length : Cranial length	211.0	6.95	3.29 %
10. Mandibular height : Cranial length	15.68	0.004	2.8 %

Ligaments :

The important ligaments of the kinesis are represented in this bird. The post-orbital ligament runs from the post-orbital process to the mandible and passes above quadratojugal. The external jugomandibular ligament runs from the dorsal surface of the hind end of the quadratojugal to the mandible. The internal jugomandibular ligament is situated below the external jugomandibular ligament towards the hind end of the quadratojugal and runs upto the articular, it reaches upto the ventral surface of the angular bone. The occipito-mandibular ligament is situated inbetween the occipital bone and the angular bone.

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MYOLOGY

Muscles of the jew :

1. The adductor group
2. The constrictor group
3. The protractor group
4. The retractor group

The adductor group raises the lower jaw.

The constrictor group depresses it.

The protractor group raises the upper mandible.

The retractor group lowers the upper mandible.

Each muscle is described on the basis of the relationship of its fibres to the tendon or aponeurosis of the origin and insertion.

1. The Adductor Group

M. adductor mandibulae externus superficialis :

This is the most superficial muscle of the adductor group. It is a very well developed massive pinnate type of muscle situated in the depression of the squamosal where it fills the major portion of the temporal fossa (**Fig.1)** It extends from the squamosal to the lower jaw.

Origin : It arises in a fleshy origin from the upper extremities of the squamosal. The muscle is provided with a medially situated tendon. The muscle fibres which arise from the squamosal are attached on either surface of the tendon.

Insertion : The muscle runs downwards and becomes tendinous towards the insertion which is on the upper edge of the dentary.

Action : The muscle acts as a very strong elevator of the lower jaw at a greater angle to the mandible.

M. adductor mandibulae externus medialis :

This muscle assumes a low triangle shape and is situated inbetween the zygomatic process of the squamosal and the lower jaw. The origin is narrow and is covered by a.m. ext. supf. muscle. The insertion is broad and covers the major portion of the lower jaw (Fig.1).

Origin : It arises in an aponeurosis from the rostral part of the zygomatic process. The aponeurosis runs forwards and downwards as a tendon. Later it twists to an angle of 90° and becomes horizontal in position. The muscle fibres arise from this tendon.

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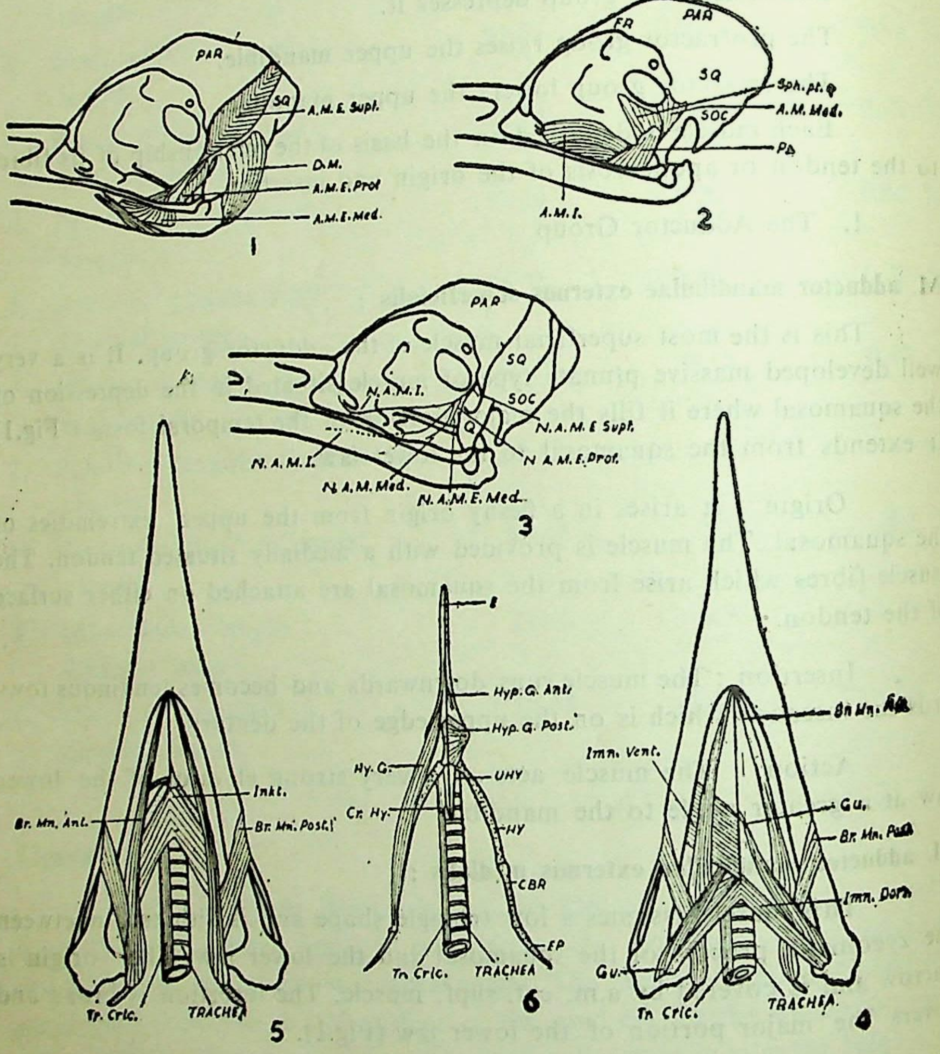
Insertion : The muscle becomes massive towards the insertion which is fleshy on the outer surface of the dentary.

Action : It acts as an adductor of the lower jaw. The contraction of this muscle causes rapid closing of the jaw.

M. adductor madinbulae externus profundus :

This muscle is the posterior most of the external adductors. Anteriorly this muscle is covered by M.a.m.ext. superficialis. It is a pinrate type of muscle possessing a tendon along the middle of the mass (Fig.1.)



Origin : It arises fleshily from the lower surface of the zygomatic process posteriorly. All the muscle fibres are attached to the tendon described earlier.

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Insertion : It runs downwards and the tendon inserts along the inner surface of the dentary.

M. adductor mandibulae medius :

The main mass of this muscle is situated deeply. The anterior part however remains superficial. The muscle runs from the orbital wall to the lower jaw (Fig. 2).

Origin : It arises in a broad fleshy origin mainly from the pleurosphenoid. A few fibres also arise from the inner surface of the postorbital process. The belly is partly tendinous and partly fleshy. As they run downwards the muscle fibres gain attachment on the tendinous ribbon.

Insertion : The tendinous ribbon unites to form a common sheath which inserts on the upper surface of the dentary.

Action : The contraction of this muscle causes a rapid closure of the jaws.

M. adductor mandibulae internus :

This is a very well developed massive muscle which runs from the palatine to the lower jaw (Fig.2). It consists of an outer and an inner part, which are situated one below the other.

Origin : The outer part arises from the dorsal surface of the palatine, wheras the inner one arises slightly below from the ventral side of the palatine. Both the parts arise fleshily.

Insertion : The muscle runs backwards and downwards. The outer part is fleshily inserted on the postero-dorsal surface of the angular behind its articulation with the quadrate. The insertion of the inner part is on the angular anterior to the insertion of the outer one.

Action : The principal function of this muscle is to draw the tip of the upper mandible downward. But as the muscle inserts on the inner surface of the lower mandible they tend to draw the lower mandible upward.

M. pseudotemporalis :

This is a moderately developed muscle. It is triangular in shape. The muscle is narrow towards the origin but gradually becomes broad towards the insertion. The muscle runs from the quadrate to the upper surface of the lower jaw. The distal part of this muscle is covered by a.m. ext. superficialis muscle (Fig. 2).

Origin : The origin which is fleshy (partly) and partly aponeurotic, is from the orbital process of the quadrate. The muscle runs forwards and downwards.

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Insertion : It inserts on the dentary along its posterolateral side of the inner surface.

Action : The muscle performs the dual function of the adduction of the lower jaw and retraction of the upper beak.

2. The Constrictor group.

M. depressor mandibulae :

It is a well developed massive muscle and runs from the occipital to the lower jaw. It has a broad origin and narrow insertion and thus it assumes a triangualr shape (Fig. 1).

Origin : The muscle arises from the exoccipital. Towards the origin it is provided with an aponeurosis on the outer surface. The muscle is broad towards the origin and becomes narrow as it runs downwards.

Insertion : The muscle inserts fleshily on the outer lower surface of the angular.

Action : It depresses the lower jaw.

3. The Protractor group.

M. Sphenopterygoquadratus :

This muscle is of a palmate type. It runs from the outer surface of the orbital wall to the inner surface of the quadrate.

Origin : The muscle arises in a broad fleshy origin from the pleueosphenoid below the optic foremen and runs downwards, backards and becomes narrow.

Insertion : It inserts fleshily on the inner surface of the quadrate anterior to the quadrato-articular joint.

Action : The function of this muscle is to draw the distal (quadratal) end of the pterygoid upwards. The quadrate is attached to this and when the pterygoid moves upwards the quadrate is rotated forward, thrusting the pterygoid forward at the same time. This action pushes forward the palatire under the interorbital septum. The forward movement of the quadrate causes the elevation of the upper mandible.

4. The Retractor group :

The adductor mandibulae internus muscle does dual function of the adduction as well as retraction of the upper jaw.

5. The Muscles Acting upon the Tongue.

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M. intermandibularis ventralis :

This is a superficial muscle as viewed from the ventral side and developed as a thin sheet of obliquely directed parallel muscle fibres. It is situated inbetween the mandibles (Fig. 4).

Origin : The origin is fleshy from the inner surface of the dentary

Insertion : The muscle inserts fleshily along the midventral line where it meets the feellow of the opposite side.

M. intermandibularis dorsalis :

This is a parallel type of muscle and is represented by a narrow strip.

Origin : It arises in a narrow fleshy origin along the outer sufrace of the angular bone (Fig. 4). The muscle runs forwards and inwards.

Insertion : The muscle inserts fleshily on the urohyal sheath where it meets the fellow of the opposite side.

Action : Both the parts, ventralis as well as dorsalis depress the floor of the mouth.

M. interkeratoideus :

This muscle forms a thin sheet, broader towards the origin and narrow towards the insertion. It is situated inbetween the urohyal sheath and the lower end of the ceratobranchial (Fig. 5).

Origin : The muscle arises fleshily from the urohyal sheath from where it runs downwards and becomes narrow.

Insertion : The insertion is fleshy on the inner surface of the ceratobranchial.

Action : M. interkeratoideus raises the hyoid apparatus.

M. branchiomandibularis :

This is a broad band of muscle which extends from the anterior inner surface of the mandinble to the posterior end of the ceratobranchial. It is a well developed muscle and consists of an anterior and a posterior part. Both the parts arise fleshily from the inner surface of the mandible. (Figs. 4 and 5).

Origin : The anterior part arises in a narrow fleshy origin from the dentary. The muscle becomes broad as it runs downwards. The posterior part also arises from the dentary below the origin of the anterior one. Both the parts run downward.

Insertion : The anterior part is inserted fleshily on the ceratobranchial and hypobranchial, where it almost twines around these bones.

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Action : These parts play a great role in raising the tongue.

M. gularis :

This muscle is situated on the ventral side and is superficial in position. It is well developed and consists of an anterior and a posterior part (Fig. 5).

Origin : Both the parts are inserted fleshily. The anterior one of these is inserted on the entoglossum. The insertion of the posterior part is on the urohyal sheath where it meets the fellow of the opposite side.

Action : It lowers the tongue.

M. hyoglossus :

It is a long thin sheet of muscle, a major portion of which runs close to the outer lateral surface of the ceratobranchial (Fig. 6).

Origin : It arises fleshily mainly from the posterio-ventral surface of the ceratobranchial. Some fibres arise also from the lateral surface of this apparatus.

Insertion : The muscle runs upwards and inwards and inserts tendinously on the entoglossum.

Action : The muscle depresses the tongue.

M. hypoglossus :

This is a very well developed muscle. It is situated in the anterior region of the hyoid apparatus. It consists of an anterior and a posterior part (Fig. 6). The anterior part is a strap like when the posterior one is fan shaped.

Origin : The anterior part arises fleshily from the postero-lateral process of the entoglossum. The muscle runs forwards and inwards and meets the fellow of the opposite side towards the median axis of the entoglossum. The posterior part is broad towards the insertion. It arises from the ventro-laterel surface of the basihyal fleshily. It runs laterally forwards.

Insertion : The posterior part inserts fleshily on the inner surface of the lateral process of the entoglossum.

Action : The lateral movements of the tongue is due to contraction of these muscles.

DISCUSSION

As stated earlier during its flight Green Bee-eater spots a flying insect it makes a rapid flight and darts on its prey. After capturing the prey the bird does not engulf the animal as a whole because of its large size.

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The prey is then battered on some hard surface. The animal thus killed is then engulfed by the bird. During this operation the Bee-eater holds the prey tightly.

The bill is less massive and forcep like. The longer and slender arms of the bill confer greater advantage in capturing the larger insects (Rawal, 1966). The narrow tip of the bill enables the animal to concentrare its force at the tip for grasping the prey. The bill is relatively wide (9.30) at its base. This facilitates the hold of the prey even in horizontal condition. Further the well marked kinesis of the skull provides wide gape for engulping the prey.

This bird takes its food while on wings, both the function of adduction and adduction of the lower jaw is equally important. During the flight at the time of attack on prey it requires a sudden opening of the lower jaw. This function is carried out by adductor muscles. After the capture of the live prey it is to be hold fast. For this purpose the bird requires equally powerful adductors.

A series of adductor muscles bring about the adduction of the lower jaw. An effective adductor is an advantage to the insect eaters where an attempt to escape on the part of the prey is most likely. For this purpose the bird requires strong adductors. A study of the muscles concerned reveals that superficial member of the external adductors is comparatively massive and possesses a broad base towards the origin and the arrangement of its fibres is of pinnate type. As studied by number of workers including Grant (1942), the pinnate nature of the muscle provides a shorter but more powerful pull. The medialis and profoundus part of the same series and medius muscle are of pinnate nature and combined action of all these muscles cause a rapid closure of the jaw.

The adductor mandibulae internus muscle of this bird plays a dual role as an adductor of the lower jaw and the retractor of the upper jaw. In Green Bee-eater, the kinesis of the upper jaw is also remarkable and the function of retraction assumes a significant role due to two parts of the internus muscle. A broad and narrow insertion of this muscle ensures an exertion of a great pull.

Like adductor mandibulae internus muscle, the pseudoten.poralis muscle also plays a dual role. In this bird the development of the muscle is of normal type.

M. depressor mandibulae is comparatively well developed for the rapid opening of the lower jaw but it does not divide into two parts which is a normal case in the gaper where the bill is opened against the

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resistance of the earth (Beecher, 1951; Rawal, 1968). Yet the broad fleshy origin and narrow insertion provides a powerful adduction.

Due to quick action of the adductor muscles, there is every chance for the forward movement of the mandible causing disarticulation at the quadrate. However such a disarticulation is prevented by the tension caused by the external jugomandibular ligament. The occipitomadibular ligament maintains an upward tension on the closed mandible and keeps the articulation tight.

Though the tongue is long it seemes that its role in handling the prey is neglible. The muscle pattern does not show significant specialization

ACKNOWLEDGEMENTS

I extend my thanks to Dr. M.S. Dubale, Head of Zoology Department, Gujarat University, for kind guidance.

SUMMARY

The ability of the Green Bee-eater, to dart on the prey is generally well known, but the modifications which are present in the structure of the head-enabling this comparatively small bird to perform such a feat, have apparantly received little attention. The behaviour of the bird while feeding on insects by a rapid flight as it spots them flying. After capturing the insect prey it generally batters the prey upon a branch of the tree and crushes it before swallowing.

The adaptations for such feeding behaviour is studied in detail. Some aspects such as the morphology of the head, i.e. bill structure, tongue jaw muscles and tongue muscles are described and their role is correlated with the feeding adaptations.

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EXPLANATION OF THE DIAGRAMS
PLATE

Merops orientalis orientalis, Latham

Fig. 1. Lateral view of the superficial muscles of the jaws.

Fig. 2. Deeper view of the jaw muscles after the removal of superficial layer.

Fig. 3. The innervation of the nerves to the jaw muscles

Fig. 4. Superficial muscle layer of the tongue as viewed from the ventral side.

Fig. 5. Muscles shown after the removal of the superficial layer in figure 5

Fig. 6 The Deepest layer of the tongue muscles.

Abbreviations :

A.M.E. Med.-Adductor mandibulae externus medialis ; A.M.E.Prof-Adductor mandibulae externus profundus: A.M.E. Supf-Adductor mandibulae externus superficialis; A.M.I.-Adductor mandibulae internus; A.M. Med-Adductor mandibules medius; Br. Mn.-Branchiomandibularis (Ant.-anterior Post-posterior); CBR-Ceratobranchia; E-Entoglossum; Fr.-Frontal; Hy-Hypobranchial; Gu-Gularis Hy. G-Hyoglossuus; Hyp. G. ant.-Hypoglossus anterior; Hyp. G. post-Hypoglossus posterior; Imn. Dors.- Intermandibularis dorsalis; Imn. Vent.-Intermandibularils ventralis; Inkt.-Interkeratoideus; PAR-Parietal; Ps-Pse Pseudotemporalis; Q.-Quadrate; Scc. Supraoccipital; Sph.pt. q.-Sphenopterygo-quadratus; Sq-Squamosal; N.A.M.E. Med- Nerve supply to adductor mandibulae externus medialis muscle, etc.

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IONIC ANTAGONISM IN ZIRCONIUM OXIDE SOLS

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When a sol is coagulated by a mixture of electrolytes, there are three possibilities :

(*a*) The coagulation value of the mixture of electrolytes is less than the coagulation value of either of the individual electrolyte.

(*b*) Taking the coagulation value of individual electrolyte as 100%, the coagulation value of the mixture is more than 100% taking into account the arithmetic proportion of the electrolytes used.

(*c*) The coagulation value of the mixture is greater than the coagulation value of the individual electrolyte.

The phenomenon under (*a*) is referred to as sensitization and (*b*) as well as (*c*) as ionic antagonism. The ionic antagonism in the case of Zirconium oxide sol was determined with a mixture of electrolytes with anions of varying valence as follows :

The coagulation values of both the electrolytes, e.g. potassium chloride (*a*) and potassium sulphate (*b*) were first determined. Then, a series of solutions was prepared containing (*i*) identical quantities of (*a*) (say 25% of the coagulation value) and (*ii*) required quantities of (*b*). The coagulation values of the sol were determined as described earlier[1]. The experiment was repeated with 50% of the coagulation value of (*a*) and (*b*) being added in the required amount to coagulate the sol. A number of pairs of electrolytes was studied. In all, two sols of different purity were studied. The results obtained are summarized in Table I.

When the sol is coagulated by a mixture of electrolytes, in general the additive rule is obeyed. Purity has little effect on ionic antagonism. There is slight sensitization when one of the coagulating ions is monovalent while slight antagonism is observed with trivalent ion as the coagulating ion.

Ionic antagonism is observed when either hydrogen ion or zirconium ion[2] is one of the coagulating ions. This is, however, a special case as these are the stabilizing ions. Hence, one may conclude that marked ionic antagonism is not observed in the case of zirconium oxide sols (as compared to arsenic trisulphide and Selmi sulphur sol).

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The phenomenon of ionic antagonism is still not well understood. As Ghosh[3] has stated, "The ionic antagonism is, however, usually observed for electrolytes of widely different coagulating powers and is limited to some specific electrolytes and sols."

Thanks are due to Prof. A. M. Trivedi for keen interest in the work. Thanks are also due to Ahmedabad Education Society for laboratory facilities.

TABLE I

Mixture of electrolytes a	b	Ionic antagonism considering mixture of a+b.
KCl M/5	K_2SO_4 M/200	Slight sensitization
,, ,,	$K_3Fe(CN)_6$ M/400	,, ,,
K_2SO_4 M/200	KCl M/5	Slight sensitization
,, ,,	Na_2SO_4 M/200	No Antagonism
,, ,,	$K_3Fe(CN)_6$ M/400	No Antagonism.
,, ,,	$K_4Fe(CN)_6$ M/500	Slight Antagonism.
$K_3Fe(CN)_6$ M/400	K_2SO_4 M/200	No antagonism
,, ,,	Na_3PO_4 M/400	Slight antagonism
,, ,,	$K_4Fe(CN)_6$ M/500	,, ,,
Oxalic acid M/100	KCl M/5	,, ,,
,, ,,	K_2SO_4 M/200	Distinct antagonism
,, ,,	$K_3Fe(CN)_6$ M/400	Slight antagonism
Citric acid M/100	KCl M/5	,, ,,
,, ,,	K_2SO_4 M/200	,, ,,
,, ,,	$K_3Fe(CN)_6$ M/400	,, ,,
sulphuric acid 0.0242M	KCl M/5	Distinct antagonism
,, ,,	K_2SO_4 M/200	,, ,,
,, ,,	$K_3Fe(CN)_6$ M/400	Slight antagonism
Phosphoric acid 0.016M	KCl M/5	Slight sensitization
,, ,,	K_2SO_4 M/200	Slight antagonism
,, ,,	$K_3Fe(CN)_6$ M/400	,, ,,

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STUDIES ON CHANGE OF CONDUCTIVITY DURING SLOW COAGULATION

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Change in conductivity during coagulation is a complex phenomenon. Smoluchowski[1] considered the influence of cataphoresis of suspended particles on specific conductance. Chaturvedi and Bhattacharya[2], Joshi and Hari Mohan[3], Chaturvedi and Bansal[4] studied the change in conductance on coagulation of a number of sols. In the present investigation, conductance of negatively charged iron oxide sol was measured in the process of slow coagulation with KCl, $BaCl_2$ and $AlCl_3$. 2 ml. of the sol was taken and its coagulation value was determined using KCl, $BaCl_2$, $AlCl_3$ as coagulants so as to coagulate the sol in four hours.

The specific conductance of the sol (liquid A) without adding the electrolyte was determined and a solution in water containing NH_4Cl was prepared having the same conductance and pH as that of the sol. This solution was called liquid 'B'. To three samples of solutions A & B each, the requisite quantity of electrolyte KCl, $BaCl_2$ and $AlCl_3$ was added; the conductivity of the system was determined with time. The cell constant of the cell employed was 2.417 cm^{-1}. The temperature was kept at 35°C. The results are summarized in Tables I & II.

Table I

Conductivity of dispersion medium alone and with electrolytes.

Electrolyte	*Concentration mM/l*	*Specific conductivity mhos cm^{-1}*
Dispersion medium	0.0	2.43×10^{-4}
KCl	5.5	7.43×10^{-3}
$BaCl_2$	1.05	3.74×10^{-4}
$AlCl_3$	0.525	3.16×10^{-4}

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TABLE II

Conductivity of the sol in presence of an electrolyte in quantity to coagulate sol in four hours.

Time in minutes	Specific conductivity (K) mhos cm^{-1}		
	KCl $K \times 10^3$	$BaCl_2$ $K \times 10^4$	$AlCl_3$ $K \times 10^4$
3	7.25	4.01	3.15
10	7.25	4.01	3.15
20	—	4.00	—
30	7.25	4.00	3.15
60	7.25	3.98	—
90	7.23	3.98	3.15
120	7.23	3.98	3.15
150	7.23	3.98	3.15
210	7.23	3.97	3.15
240	7.21	3.97	3.15

DISCUSSION

Process of coagulation involves neutralization of the charge followed by a more leisurely process of coalescence of particles. One way of investigating the first part of the process is to study the variation of charge on the colloidal particle with addition of an electrolyte. The same may be studied simultaneously by determination of conductivity. In the present case, concentration of electrolyte is much that coagulation takes place after four hours. The conductivity of the system was compared with that of intermiceller liquid prepared artificially. In all the cases, the change in conductance is instaneous process within the limits of accuracy of measurement indicating that neutralization of charge takes place instantaneously. This agrees with the views of previous workers[2]. It may be noted that the conductivity of intermiceller liquid appears to be slightly higher than Sol + KCl and Sol + $AlCl_3$ and slightly lower in case of Sol + $BaCl_2$. The difference is, however, very slight and may not be significant.

Thanks are due to Prof. A. M. Trivedi for interest in the work.

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DISSOCIATION CONSTANTS OF DIETHYLDITHIOCARBAMIC ACID IN ACETONE—WATER MIXTURES

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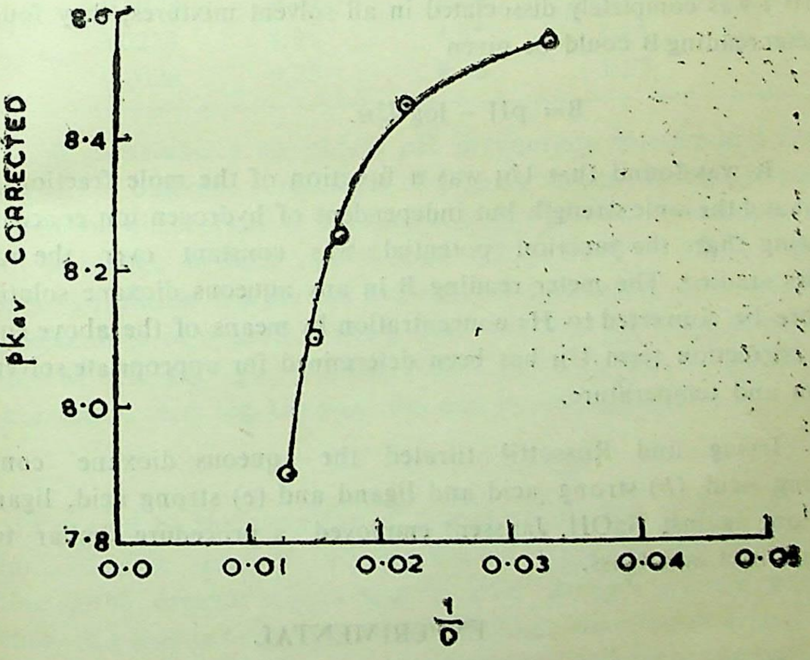
In the strictest definition of pH, it is related to dilute aqueous solutions, if it is to retain its full significance in terms of hydrogen ion concentration. The comparison of acidities, in partially aqueous solutions or non-aqueous solutions, is a problem of far greater complexity. It is necessary to look closely into the meaning of the term acidity and the role of the solvent in acid-base phenomenon. The numerical value of dissociation constant is assigned with reference to a particular standard state. The value of



dissociation constant depends upon amongst other factors, on the nature and properties of the medium. Amongst those properties, dielectric constant plays an important role. The primary effect of decrease in dielectric constant is to increase the attractive forces between ions of unlike charges. In other

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words, lower the dielectric constant, less is the dissociation. If oppositely charged ions are created from neutral molecules in the dissociation process, the dissociation constant of the acid will be considerably reduced by lowering of the dielectric constant. If the dissociation is an isoelectric process, the change in dielectric constant will have smaller effect upon the point of equilibrium[1].

Measurement of hydrogen ion activity by means of a pH meter which may be standardized employing aqueous buffers is significant for aqueous solutions only. Measurement in mixed solvents will be of significance when buffers are prepared in the same media. Many attempts have been made to interpret the measurements of acid-base equilibria in non-aqueous media.

Van Uitert and Haas[2] used the cell

--GE/ HCl in aqueous dioxane. Mole fraction dioxane n_2, ionic strength μ	/ KCl salt bridge	/ Hg_2Cl_2 (S) Hg (l)+

in conjunction with an instrument to give direct readings of pH. Assuming that HCl was completely dissociated in all solvent mixtures, they found that the meter reading B could be given

$$B = pH - \log U_H.$$

It was found that U_H was a function of the mole fraction of the solvent and the ionic strength but independent of hydrogen ion concentration, indicating that the junction potential was constant over the range of acidities studied. The meter reading B in any aqueous dioxane solution can therefore be converted to H^+ concentration by means of the above equation, if the correction term U_H has been determined for appropriate solvent, salt medium and temperature.

Irving and Rossotti[3] titrated the aqueous dioxane containing (*a*) strong acid, (*b*) strong acid and ligand and (*c*) strong acid, ligand and metal ion; against NaOH. Janssen[4] employed a procedure similar to that of Van Uitert and Hass.

EXPERIMENTAL

In the present work, the calibration of pH meter was carried out following the procedure of Janssen. The meter readings of the solutions of NaDDC (Sodium diethyl dithiocarbamate) and $HClO_4$ prepared in different mixed solvents have been determined. Besides water, acetone was used as

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solvent. The dielectric constants of water and acetone are 80.4 and 21.4 at 20°C respectively. Acetone used was of A.R.B.D.H. quality and was distilled before use. $HClO_4$ and $NaClO_4$ were of G.R. grade and the acid was standardized against dry Na_2CO_3 and borax. The pH measurements were carried out at 30±1°C using Leeds and Northrup pH meter equipped with a glass and calomel electrodes. As the mixture of NaDDC and $HClO_4$ showed a gradual change in pH, the mixtures were kept for about 24 hours and the meter reading B of the solutions were subsequently measured. In all cases, the ionic strength was maintained nearly about constant by adding 0.1M $NaClO_4$. The values of pK_1 and pK_2 (dissociation contants) were read by noting the pH values corresponding to 3/4 and 1/4 neutralization. The results are only summarized in Table 1. The pH meter was standardized by employing the standard aqueous buffer solution of pH 4.0, 7.0 and 9.2 at 30°C. The correction term log U_H was calculated as follows :

TABLE 1

Acetone %	$1/D$	pK_1	pK_2	*pKav*	*pKav corrected*
0·0	0.0127	8.20	7.60	7.90	7.90
20.0	0.0145	8.45	7.90	8.20	8.10
40.0	0.0173	8.65	8.20	8.40	8.25
60.0	0.0218	8.95	8.35	8.65	8.45
80.0	0.0328	9.25	8.45	8.85	8.55

It is necessary to obtain pH in aqueous solution and the meter reading (B) in different percentages of organic solvent. Instead of calculating hydrogen ion concentration stoichiometrically, a blank set containing 50 ml. of 0.01 M $HClO_4$ in water was titrated against 0.1M NaOH in weter. The continuous titration was carried out and pH readings were noted. Now, for each percentage of organic solvent, meter readings (B) were noted by titrating, 0.01M $HClO_4$ against 0.1M NaOH both being in 0.1M $NaClO_4$. The correction term log U_H was obtained by the equation

$$\log U_H = pH - B$$

log U_H should be the same for all ranges of pH for a particular solvent system and ionic strength, i.e., log U_H is dependent only on the the mole fraction of the organic solvent and on ionic strength of the medium. In practice, this was not so. The meter readings were found erratic and less reproducible in the alkaline range and in the system containing more than 60% of the organic solvent. This difficulty has been previously encountered[5].

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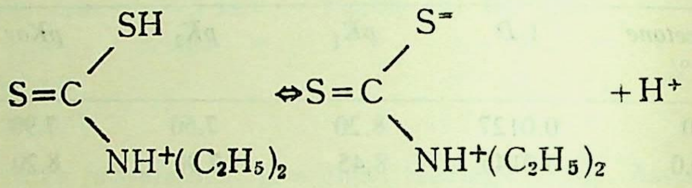
The values of log U_H determined as described above were as follows :

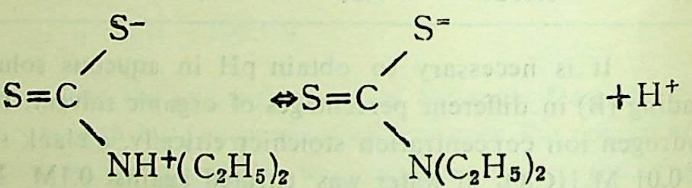
cetone %	log U_H
20	–0.10
40	–0.15
60	–0.20
80	–0.30

DISCUSSION

Table I shows that the values of pK_1 and pK_2 increases with increase in the percentage of organic solvent. Increase in pK_1 is more marked than that of pK_2. pK_1 corresponds to separation of unlike charges and is affected o a greater extent.



pK_2 corresponds to isoelectric charge and is affected to a lesser extent.



For the consideration of variation of pK values in mixed solvents, we shall for convenience take up the relation of average dissociation consant (meter reading when the acid is half neutralised), i.e., pKav. It varies from 7.90 to 8.55 as the percentage of organic solvent is increased from 0 to 80%.

The increase in pKav with decrease in dielectric constant is in accordance with the Nerst–Thompson rule[6] which states that the degree of dissociation of solute in various solvents, increases with increase in dielectric constant.

According to Born[7] free energy per mole is given by

$$\Delta F = -\frac{N\epsilon^2}{2D\gamma}$$

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where N is Avogadro's number, D=dielectric constant, ϵ =electronic charge, r = ionic radii.

If the ionic radius is influenced by change in solvent, the following expression for K can be written[8]

$$-\log K=\frac{a}{D}+\frac{\Delta F^{\circ}C}{2\cdot 303RT}$$

where 'a' is constant. If the above equation is strictly applicable the graph of pK against 1/D will be a straight line. Lynch and La Mer[9] have calculated the minimum distance of approach of two ions, 'r', i.e.. the average diameter from the curve of pK against 1/D.

From the Figure the slope may be calculated when D changes from 78 to 50. The value of 'r' (r=243.3/slope) comes out to be 2. 7 A°. This value of 'r' changes (2.7 to about 10 A°) when dielectric constant falls below 50. Thus the value of 'r' is not constant in the same system. This suggests that the above equation is far too simple and it is merely an approximation. Lynch and La Mer have concluded that 'r' increases with decrease in dielectric constant of the system. Harned and Dedell[10] have calculated the mean ionic radii of a number of acids in warer - dioxane mixtures from 0 to 70 % The values for propionic acid were 0.74 A° in pure water and 3.76 A° in 70% dioxane. Hence the results obtained in the present work are in agreement with conclusions of the above workers.

Thanks are due to Prof. A. M. Trivedi for interest in the work.

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AGAR AGAR AND ALGINATE RESOURCES OF INDIA

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Introduction :

Sea weeds are the only sources of two industrially very important phycocolloids, viz., agar agar and alginates. It should be admitted that richness of sea weeds of India cannot stand comparison with some of the temperate countries, however, India has coastal line of about 3600 miles with variety of habitats in which numerous species of brown and red algae are thriving. This natural wealth hidden in marine plants is yet sparingly explored and there is a great need of well planned, centrally organized enterprizing reasearch projects to assess and industrially utilize sea weed resources of the country.

Feasibility of developing major industries based on products of sea weed is often questioned. However, available mass of data in the foreign countries does not support the above contention. In fact some enterprizing people have undertaken the production of agar agar and alginates at industrial level even in this country and they need the support of research institutes engaged in works on sea weeds.

In the present paper information gathered from published literature, reports and communications has been compiled. Data obtained by personal observations and discussions with the research workers and industrialists, engaged in sea weed products are also incorporated.

The paper is divided in two sections: I. **Agar agar** and **II. Alginates.** Under each section the historical account; chemistry of Phycocolloids; their uses; informations regarding survey, harvest data, and drift survey; prodution at industrial level; Mariculture and sea farming; are incorporated. Some suggestions on research programme and training are also given in this note. Bibliography of the literature is also attached at the end.

Information on sea weed exploration and on their product embodied in this paper has been obtained from various reports and communications of various research institutes in this country.

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1. Agar agar

History :

Agar agar is usually defined as an extract from certain red sea weeds which dissolves in hot water and requires only 1% solution to set as gel on cooling. Upto 1939, Japan was the only country which was producing agar. India imported about 29 tons of agar during 1934-37 (Thivy, 1958). About 20-30 tons of agar is imported per annum at present. During the last world war the import of agar was stopped and Board of Scientific and Industrial Research tried to encourage indigenous production of agar in 1940. Bose, Karimullaha and Siddique (1943) published a report of production of agar from *Gracilaria* from Travancore. Chakraborty (1945) and Mitra (1946) reported the production of agar from *Gracilaria* growing in Chilka lake. Joseph and Madhavan extracted about 400 lbs. of agar from 4.5 tons *Gracilaria* during 1942 to 1946 at Travancore University. After independence much work has been done in this field at individual level.

Chemistry of agar agar and agarophytes. Agar agar is made up of two components: Agarose and Agaropectin. Agarose is made up of alternating 1, 3-inked D-galactose with 1, 4 linked 3, 6-anhydro-L-galactopyranose. (complex polysaccharides) while agaropectin is sulphated polysaccharide containing a mixture of sulphuric acid, D-glucuronic acid, pyruvic acid with D-galactose; and 3, 6-anhydro-L-galactose. Usually agarophytes contain carragheenins along with agar agar. It is composed of alternating chain of 3, 6, anhydro D-galactose with galactose 4-sulphate.

The ge lstrength of agar agar depends upon sulphate content. If sulphate content as compared to sugars is higher the gelling power is less. Sugar sulphate ratios of agarophytes should be carefully worked out. Doshi and Rao (1967) have shown that sulphate content reduces on irradiating air dried sea weeds.

Thivy 1959 has worked out properties of Indian agar as follows:

Moisture : 16-18 %
Ash : 2-3 %
Gel strength : of 2 % soln. 180 g.
Setting temp. : 39-43°C
Yield on dry weight of sea weed : 40-46 %.

Kappana & Rao (1963) and Krishnamurthy (1965) have also analysed some agarophytes for their chemical constituents such as sodium, potassium,

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calcium, magnesium, sulphates, carbonates, manganese, iron, etc. Extension of such a study would enable us to understand the physiolcgy of agar yielding algae and help us in mariculture and sea farming.

Data regarding gel strength of agar obtained from different agarophytes of India is shown by Dr. U. M. Rao of Central Marine Fisheries Station, Mandapam. They are as follows :

Sea weeds	Gel strength
Gelidiella acrosa	300 gm/cm²
Gracilaria lichenoides	120 gm/cm²
Gracilaria verucosa	125 gm/cm²
Gracilaria corticata	20 gm/cm²
Gracilaria crassa	140 gm/cm²

From the above data it appears that the **Gelidiella** is the best source for agar but as mentioned elsewhere the gel strength depends on many factors and attempts should be made to improve the gel strength of agar from *Gracilaria* which apprears to be promising source of agar for this country.

Uses of Agar agar : (*i*) The most common use of agar is in preparation of culture media for microbs. In fact the industries of antibictics are heavily dependent on agar supply (Marshall et al, 1949). (*ii*) Agar is finding place in Pharmaceutical industries in preference to pectin and other colloids. It is used as glycerine substitute, a pill excipient, an ointment base, in wound dressing, in blood clotting, to stabilise an emulsion to carry vitamins, in manufacture of plastic material for dental imprints and others. (*iii*) Food industry also use agar. It is useful in the preparation of fccd prescribed for diabetic persons. It is used in canning meats and fishes because of its de tinning action. It is used as thickening agent in cream, pudding, icecream, fruit salad, soups, etc. It is considerably used in confectionary. It is also as cleaning agent for wines and bear. (*iv*) Agar is important in production used of greaseless cosmetics, in face creams and soaps, hand lotion and even in shoe polish. (*v*) In textile and leather industries it forms a sizing medium for fabrics a thickener in dying and printing. (*vi*) In manufacture of tungsten wire for electric lamp agar graphite gel is very useful. (*vii*) Agar is also used in adhesive in manufacture of plywood, in manufacture of photographic films as an activator in Nicotin spray, in electroplating of lead, sizing of papers, etc.

Food value of agar is negligible. It is not affected by any human enzyme. However, it has been found that agar promotes the growth and

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germination of certain fungal spores. Robbins (1939) suspected some growth substance in agar. There is a scope for further research work in this field.

World resources of Agar : Marshall et al. (1949) have given informative account of world situation of agar production. Much progress must have been made since then but it gives us an idea that when countries like USA, UK, Japan, Australia, Newzealand and USSR made considerable progress we were in an initial stage. Marshall et al (1949) have given interesting account of various materials and methods utilized by different countries in production of agar. The study of this work might enable to develop our own techniques.

Indian agarophytes and their distribution : Indian coast is rich so far as number of species of Red algae is concerned. We have no complete check list of species of Rhodophyceae occurring near Indian coast. However, it is now known that some of the Red algae are agar producing ones. Species of *Gelidiella*, *Gracilaria*, *Halymenia*, *Calliblepharis*, *Sarconema*, *Hypnea*, *Corallopsis*, *Spiredia*, *Gigartina*, *Hymnogongrus* are regarded as agarophytes. No systematic attempt has been made to screen the agar yielding potentialities of many other common species of Red algae. The efforts are concentrated round about traditional plants such as *Gelidiella* and *Gracilaria* After determining the aboundance of occurrence of red algal species an attempt should be made to screen them for their agar content.

Sea weed localities : Commonly known sea weed localities of India are: Okha, Dwarka, Verawal, Bombay, Ratnagiri, Karwar, Cannancri, Verkala, Vizhingam, Enayam, Colechel, Cape Comerire, Tuticorin, Manapad, Mandapam and near by islands, Tranquebar, mahabalipuram, Madras, Vizagapatanum, and Chilka lake. Out of them area of Okha, Veraval, Tuticorin and Mandapam are reported to be very rich qualitatively as well as quantitatively.

It appears from the literature that survey made for the sea weeds are resticted to litoral zones and to the places which are near the towns. We have yet to ascertain the sea weed biomass of the sea coast in between places mentioned above. Survey of many small and big islands situated in Indian territorial waters may also give us the estimates of sea weeds flora. Fisheries departments of the coastal states in association with team of young and energetic algologists can fulfil the task of the survey of every inch of coastal line and all species of the sea weeds. It is likely that like mines of mineral deposits there may be rich pockets or beds of economically important sea weeds still unknown to us.

It should be noted here that many of the temperate countries have rich flora of brown sea weeds but some of them are still depend upon

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external source of red sea weeds for the manufacture of agar. From our country alone as much as 220 tons of red sea weeds, viz., *Gelidiella* are exported annualy. This speaks for the indigenous resource of agarophytes. If this export is stopped and the raw material is utilized in this country we can become self dependent for our agar requirements.

Harvesting of Agarophytes : The method of collection of agarophytes is by hands from exposed sea coast during the low tide. In most cases drifted thallii are picked up. Moreover collection is largely restricted to litoral zone.

No attempts seem to have been made to find out the feasibility of mechanical methods. Mechanical method of collection of agarophyte might be the first step to feed the industry with raw material. Collection on exposed coast and under water collection may pose different problems.

Varma (1962) reports that in Pamban area economically important sea weeds were not found below the depth of seven meters. This might be a special case, which may not be true for entire Indian sea coast Dr. F. E. Johnes during his visit at Bhavnagar in February, 1967, remarked that light would penetrate at more deeper depth in sea water of Indian coast and therefore, it is, likely that sea weeds may occur at deeper depth. No attempt has been made to estimate the algal flora at depth by diving method which is the only reliable method for the correct estimation.

Most of the estimation on harvest data and drift survey are perhaps the gross estimation.

Moreover, the best season for the harvesting individual sea weeds has to be determined having regards to the growth and sporing period of the plants. Correlation between gel strength, sporulation and growth has also to be ascertained as ultimate aim is to get a product with a best available gel strength. Some suggestions have been made elsewhere regarding methods of harvesting of sea weeds.

Drift Survey and Harvest data on Agarophytes : Work on Drift survey and harvest data of agarophyte should be the primary step in the programme. India has 3,600 miles of sea coast and yet studies on drift survey annual harvest of agarophytes are made in a few localities in south, at Chilka lake and recently at Okha. (Mitra, 1946 ; Koshy and John, 1948; Thivy, 1951, 1958, 1961, Chacko and Malu Pillai, 1948; S. Rao et al 1964; Varma and Rao, 1965; Krishnamurthy et al, 1965; Desai, 1965). Data regarding drift survey of agarophytes are set in Table 1.

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TABLE 1

Records of harvest data of agarophytes

Authors	*Places*	*Algae*	*Estimation Harvest (Approx.)*
Mitra (1946)	Chilka	*Gracilaria*	4-5 metric ton/annum
Koshy et al. (1948)	Cape Commerine		1 metric ton/annum
Varma and Rao (1962)	Pamban	*Gracilaria*	35 tons
Thivy (1958)	Pamban	—	7 metric tons
Chidambaran & Unni (1947)	Tanjor	'Sea weeds'	120 tons
Krishnamurthy (1965)	Pamban	*Gracilaria*	40.5 kg/3 months
		Geldiella	Nil
		Hypnea	19.6/3 months
	Idinathakarai	*Gracilaria*	20.50 Kg./3 months
		Hypnea	6.75 "
Desai (1965)	Gulf of Kutch	*Gracilaria*	20 tons
	Gulf of Mannar	*Gelidiella*	300 tons
		Gracilaria	3000 tons
Thivy (1958)	Mandapam area	Agarophytes	3 lbs/sq. meter 10 tons/annum from the area
Thivy (1965)	Okha-Adatra	Ses weeds	58 tons
CMFRI (Mandapam)	Mandapam	*Gelidiella*	51.05 toms/annum (dry wt.)
		Gracilaria	15.50 tons/annum (dry wt.)

The above literature and data suggest that—

1. the work of survey is restricted to certain localities.
2. the methods employed by various workers are not standardized, and hence it is difficult to compare the data.
3. facts regarding the total area surveyed, number of observations made, seasonal variations in the standing crops, and statistical norms do not become evident in some of the works. All these are very essential in survey like this.

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4. in some cases the weight taken is whether fresh of dry one is also not mentioned.

Thus there is an urgent need of reassessing our resources for agar on more scientific bases with standadized technique.

Chapman (1950) has reviewed various methods of sea weed estimation. Two principal methods are, by estimating—

1. fresh weight of the plants per unit area (the mean density × area of the beds).
2. mean weight of the plants per standard length (–one meter) of the shore × overall length of the shore line.

We may devise our own methods and resurvey the whole coastal line.

Processes of extraction of agar from the sea weeds : Various Indian workers have described different procedures for the extraction of agar from the sea weeds (Bose et al, 1943; Chakraborty, 1945; Karunakar et al, 1948, Mohanty, 1955; Thivy, 1961; Kappana and Rao, 1965; Srinivasan, 1967; Desai, 1965). Some authors have not mentioned the reasons or technical advantages for the modification of existing procedures.

The method of extraction is very important because any step in the extraction procedure may denature or deteriorate the quality of agar agar. The properties of agar extracted by various methods should be tested and then the process of extraction should be finalised. It is quite likely that the percentage of extraction may be high by some procedure but until it preserves required quality of agar it should not be accepted.

For example extraction of agar under high pressure might shorten the process of extraction but at the same time it reduces the gel strength by denaturing the product (Kappana and Rao, 1963). Karunakar (1943) avoided the freezing of gel for purification. Instead he steeped the gel in dilute salt solution for 96 hours. This method looks economical but the agar extracted by this method is of lower grade. Desai (1965) has suggested that cost of freezing can be avoided by flocculating the agar gel by alcohol. It is yet to be found out that this method does not affect the properties of agar. All the steps right from harvest of the algae upto the final product should be carefully studied to have agar industry functioning at maximum effeciency.

The various processes of agar agar extractions are briefly summerized in Table 2.

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TABLE 2

Processes of Agar extraction

Authors		*Process (main steps)*
1. Bose et al (1943)	...	Leaching for 18 hrs.; extraction; gel formation at 60°C; – treatment with acetic acid to remove impurity.
2. Chakraborty (1945)	...	Same as above but freezing and thawing for purification of agar gel use of active carbon for decolourizing the gel.
3. Karunakar (1948)	..	Purified the gel by steeping in water of low salt content for 96 hrs. and finally washing the gel under pressure at 230°F. After freezing the gel was dried with acetone.
4. Thivy (1961)	...	Soaking and grinding sea weeds for 24 hours prior to extraction.
5. Kappana and Rao (1963)	...	Studied the above operations comparatively and found that soaking and extraction, under pressure deteriorate the property of agar gel.
6. Patel and Rao (1965)	...	As above manufactured agar agar on pilot plant. 160 kg of agar was produced at U.S.P. specification at cost of Rs. 10/- per kg.
7. Srinivasan, R. and Santhanraj (1965)	...	Algae washed in sea water, use in for 3 days-sprinkling sea water daily in the morning-washed well in fresh water several times and sun dried to bleach pulverized, washed, mixed with boiled water at pH 6 by adding sulphuric acid, filtered-frozen, price Rs. 20/-kg. (Imported agar Rs. 40/- 220/kg. Difco, etc.)
8. CMFRI-Mandapam	...	*Gracilaria* bleached and dried in sun. Washed with fresh water and again dried-crushed in stone mortar with soft water-Pulp strained and dried- dried meal is added to hot water at 95°C.- removed sedimentation - clear gel soln. dried on plastic netting. The process claims better yield without deterioration of properties.

Srinivasan and Santhanraj (1965) have given a comparative account of variations in the properties of agar gel brought about by adopting different extraction procedures. They claim that agar prepared by their procedure is comparable with Difco agar.

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Sea Plants and Chemicals Pvt. Ltd., Madras have started manufacture of agar agar. They have followed the standard procedure. The market value of their product is Rs. 125/- per kg.

The sea weeds needed for the plant is obtaind mainly from Coast of Mandapam, Pamban, Rameshwaram, Tuticorin and other Southern Coast. The monthly requirement is 15 tons dry weight of seaweeds. The algal species uesd for the manufacture of agar is not mentioned.

The industry face difficulty in getting licences for the machinery and they need protection against imported agar from Japan.

Yield and production cost of agar agar : Shrinivasan and Santhanraj (1965) have shown that various processes of extraction affect the yield and gel strength of the agar. The weak point of otherwise valuable work that the species of sea weed is not mentioned any where. It is claimed that the highest yield, viz.; 37% can be obtained by pulverizing " Sea weed " prior to extraction. The range of yield due to various extraction processes as shown by them is between 5 to 37 %.

Central Marine Fisheries Institute has following data to offer :

Sea weeds	Yield	Gel strength
Gelidiella acrosa	45 %	300 gm/cm²
Gracilaria lichenoides	43 %	120 gm/cm²
Gracilaria verucosa	40 %	125 gm/cm²
Gracilaria corticata	38 %	20 gm/cm²
Gracilaria crassa	23 %	140 gm/cm²

The above data shows that **Gelidiella** is the best source of the agar. **Gracilaria** are fairly common sea weeds but the gel strength is low. Efforts must be made to increase the gel strength of the agar extracted from **Gracilaria** which has potentiality to be the main source of Indian agar.

Srinivasan R and Santhanaraj (1965) at Fisheries Technological Station, Tuticorin produced agar and shown that the production cost was Rs. 20/- kg. and the quality of the agar was claimed to be of foreign standard. Coast of " Madras " (Tamilnadu) State is capable of producing 3 tons of agar per annum.

Laboratory experiments followed by pilot plant trials at Central Salt and Marine Chemicals Research Institute, Bhavnagar have shown that project coast of 160 kg. of agar conforming to USP standard was estimated to be Rs. 10/- per kg. While the price of imported agar is Rs. 15–20 P.per kg.

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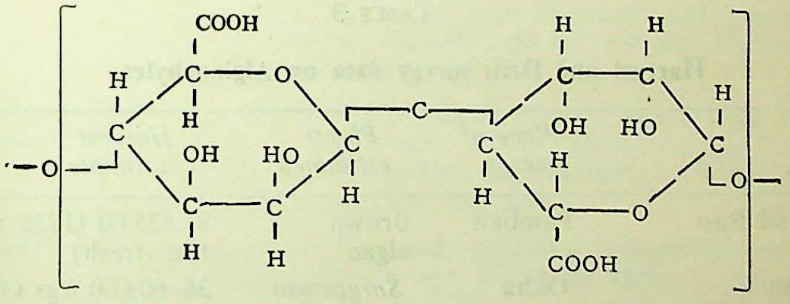
(Rao et al, 1965) C.M.F.R.I. Mandapam records indicate that the quantity of sea weeds exported from this country during 1966 is 162 · 61 M. tons which fetched the foreign exchange worth about Rs. 417/- while in 1967 it is about 198 M tons which fetched Rs. 740/-* approx. If there would have been indigenous industries to produce agar from the sea weeds we would have saved lot of foreign exchange by not importing ready made agar from abroad.

It should be remembered here as Varma (1962) has pointed out that on account of prevailing high temperature in coastal region of India agar industry cannot be established without facilities for freezing gel. Cottage industry is feasible in Japanese climate may not run in India.

Moreover the present picture of Indian resources of agarophytes alone may not be sufficient enough for feeding large industries. Even Japan has to import about 2000 tons of red algae from Peru, Chili, Formosa. Java, Africa and other countries.

II. Alginates

Alginates are hydrophillic colloidal substances extracted from brown algae. Chemically they are the salts of alginic acid. Alginic acid is a high polymer of beta-d-mannurenic acid residues so lined that the carboxyl group of each unit is free while the aldehyde group is shielded by the glycosidic linkages. The structural formula is as follows :



Alginic acid formula was emperically suggested by Dillon as ($C_6H_6O_6$) Salts of alginic acid found in sea weeds are commonly called algin. Algin has many important uses—

(*a*) **Food** : In Ice cream, candy, dehydrated soups, as a stabilizer.

(*b*) **Pharmaceuticals and cosmetics** : Tablet disintegration, laxative, lotions, ointments, suspensions, sampoo, tooth paste.

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* There appears to be uncertainty about the cost of sea weeds and their products.

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(*c*) **Textile** : Sodium alginate is compatible with all anionic dyes and with all insoluble pigments. It is used as a thickener for printing of direct cotton, disperse acetate, stabilized azoic and on synthetic fibres.

(*d*) **Paper and Paper Board** : Sodium alginate improves the printability, uniformity and smoothness of papers. It imparts resistance to the paper against organic chemicals.

(*e*) **Other uses** : To lubricate welding electrodes. It has low ash content and generate CO_2 on burning. It has low viscosity and it is resistant to microbial attack. Thus it is evident that there will be a great demand for ' Algin ' products in various industries.

Indian Alginophytes and their distribution : Brown sea weeds are reputed for their algin content. Species of cyclosporeae are considered to be rich in alginate content in comparison with other alginophytes. The most common brown sea weeds reported from India are species of *Dictyota, Padina, Hormophysa, Cystophylum, Turbenaria and Sargassum*. Other common phaeophyceae are : *Spatoglossum, Iyengaria*.

Harvest and drift survey data on Alginophytes : As compared to data on agarophytes the harvest and drift survey data on alginophytes are rare. They are more or less based on gross survey and species of brown algae are not considered while surveying. Table 3 indicates the available data on the subject.

TABLE 3

Harvest and Drift survey data on Alginophytes

Authors	*Place of survey*	*Plants estimated*	*Harvest estimate*
Varma and Rao (1962)	Pamban	Brown algae	83,835.00 (1958 metric ton (fresh)
Sreenivasa Rao et al. (1964)	Okha	*Sargassum* sp.	36-60,000 kg. (fresh) per 15000 sq. meters (Dec. '61 to Dec.'62)
Desai (1965)	Gulf of Kutch	Brown algae	20 tons (dry per 90 sq. miles
Krishnamurthy (1965)	Pamban Idinthakari	*Sargassum* & other alginate plants	(Aug. to Oct. 1965) 47.25 to 454.00 kg. (Aug. to Oct. 1965)
Iswaran (1965)	Jamnagar	*Sargassum*	10,000 tons (annually)
U. M. Rao C.M.F.R.I.	--	*Sargassum*	5.00 tons

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These data also suffer from information desired while assessing algal resources for industrial use. Some points mentioned under Drift survey of agarophytes (cf. p. 8) are also applicable here.

Extraction of Algin from Brown sea weeds

This process includes from collection of sea weeds, their transport, storage and extraction. Algin is usually extracted in form of the sodium alginate or alginic acid. It has also been extracted as calcium alginate. Different workers have adopted various processes of extraction. The main steps in process of extractions are summerized in Table 4.

TABLE 4

Processes of extracting algin

Stanford (from Desai, 1965)	: After cold water treatment for 24 hours Laminaria was digested with sodium carbonates. The resulting viscus mass was filtered. H_2SO_4 or HCl were added to precipitate alginic acid.
Green (1936) (from Desai, 1965)	: Conducted at low Temp. (50°C). Sea weeds were leached for 3 hours by 0.3 % HCl. Then it was digested by sodium carbonate, filtered. Filtered solution was slowly added to 10 % $CaCl_2$ soln. under constant agitation. Calcium alginate thus obtained was bleached and precipetated as Alginic acid by adding Hydrochloric acid.
Le Gloahee (1939) (from Desai, 1965)	: Pretreatment of sea weeds with calcium chloride. Forth flotation to remove impurities, decolourization. Final product calcium alginate.
Pillai (1957)	: He used acidified potassium permanganate as a bleaching agent.
Kappana et al. (1962)	: Air dried sea weeds were pulverized, extraction of alginic acid as above (Further details not mentioned).
Rao and Modi (1965)	: (*a*) Sea weeds-washed, sun dried, powdered, treated with N HCl. (pH 2-3) Kept overnight centrifuged, soln. bleached with sodium hypochlorite, evaporated, final product sodium alginate (*b*) To bleached soln. $CaCl_2$ soln. was added. Final product calcium alginate. (*c*) Alginic acid was precipitated from Na and Ca-alginate by treating with N hydrochloric acid.

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Shah et al. (1968)	Sea weed soaked in dilute formalin soln. overnight and dried, pulverized treated with 0-25 N HCl (2 hrs.) Then added with sodium carbonate. Final product sod. alginate. (b) Sodium alginate soln. treated with calcium chloride to get calcium alginate. Bleaching with sodium hypochloride.
Srinivasan and Santhanraj (1965)	Sargassum-dried-washed in sea water-washed in fresh water,-dried-powdered-treated with 2% HCl - (for 24 hrs.)-filtered - washed-treated with Sod. Carbonate (3%) diluted filtered centrifuged-treated with alcohol - end product alginic acid. (Sod. alginate bleached by hypochloride)
Cellulose Product India Ltd., Ahmedabad (1967-68)	Sargassum-washed-pulverised-bleached with Na hypochloride-treated with HCl (not more than 8 hrs. as prolonged treatment drops the viscosity)-filtered-treated with Sod. carbonate plus alcohol-filtered - dried-and product sod. alginate.
C.M.F.R.I. Mandapam	Sea weeds to be boiled in water, then boiling with dil. Hydrochloric acid, maceration with sodium carbonate, filteration, precipitation, bleaching (?), end product-alginic acid.

Besides above methods of extraction some points regarding conditions during the extractions have been discussed by Cameron et al. (1948), Pillai (1952) Valson (1955), Chako and Malu Pillai (1958), Pillai and Shyanamma (1959) and Iswaran (1965).

Desai (1965) has reviewed methods of alginate extraction. He has discussed processes used by Kelco Co. and Algin Corporation. He has suggested several modifications in the processes for the better results. He emphasized the importance of temperature and pH at various stages of extraction. He also belives that bleaching by sodium hypochlorite followed by sodium bisulphite is desirable. He further believes that treatment with HCl to obtain alginic acid results in degradation of viscosity. Therefore precipitation and forth flotation by industrial alcohol will directly give the precipitation of sodium alginate.

The above account shows that we are not yet very near to the standardized method of extraction of alginate. Every author claims the superiority of his method and there is a scope for the further work on above mentioned subject.

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Algin content of the sea weeds :

Chako and Pillai (1958) estimated algin content of 14 species of sea weeds and found to vary between 15 to 29 %. Kappana et al. (1962) estimated the alginic acid content of species of *Sargassum*, *Dictyota* and *Cystophylum.* There was a variation between 4.85 to 29.17 %. The highest alginic acid content was found in *Sargassum cinerimum J.* Ag. var. *berberifoloum* Grann. (19.17 %).

Cellulose product of India Ltd., Ahmedabad who have started manufacturing sodium alginate and alginic acid found that algin content of commonly available species of *Sargassum* in South India is 3–9%.

Algin content varies from species to species and even in the same species from season to season. The environmental factors may also affect the algin content of a species. Shah et al. (1967) have made some study on seasonal variation of viscosity of sodium alginate, Yet there is a great scope for the work on above subject.

Table 5 indicates the data of algin content of brown sea weeds.

TABLE 5

Algin contents of sea weeds

Sea weeds	*Algin content*	*Authorities*
Dictyota sp.	5.50 %	Kappana et al. (1962)
Padina sp.	10.35 %	CMERI (Mandapam) CMFRI
Hormophysa triquetera	18.22 %	CMFRI
Cystophylum muricatum	19·74 %	Kappana (1962)&CMFRI
Turbenaria conoides	33.74 %	CMFRI
Sargassum renerrimum (at Dwarka)	4.85 %	Kappana et al.(1962)
,, (at Sikka)	14.77 %	,,
,, (Okha)	10.80 %	,,
,, (Okha–in Feb.)	9.0 %	Shah at el. (1965)
,, (In Nov.)	15.04 %	,,
S. cinereum	29.17 %	Kappana et al.(1962)
,, (Nov. –Feb.)	21.31.15.73%	Shah at el (1965)

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In the above table the data about all the species of *Sargassum* are not included. These can be had from references mentioned in above table. This data indicates that algin content of a given species varies from places to places and from season to season. Reasons of fluctuation in algin content in the same species at different localities during the same season is not yet known. However it is understandable that if there is no variation in the genotypes the environmental factors must be controlling the algin content of a species. Study of spatial and seasonal variations in these factors will help us in efforts to increase yield of alginates from sea weeds.

U. M. Rao (1967) has shown that at Mandapam growth of *Sargassum wightii* and *Turbenaria conoides* show peaks during September and January. Work of Shah et al. (1967) report that the algin content of the sea weeds also show its maxima during these months. Thus there is a scope of investigating correlation between growth and algin content of the sea weeds.

Bidwell and Ghosh (1962) using $^{14}CO_2$ have shown that alginic acid is more repidly accumulated as compared to either laminarin or fuccidin. Seasonal fluctuations in the algin content of middle lamella of the cell wall show that this compound is directly involved in the metabolism of algae and resembles other compound in repeated breakdown and resynthesis.

The above account reveals that assessing the algin content of sea weeds pose a complex problem and physiological and ecological studies of brown algae will help us to understand algin metabolism in sea weeds.

Industrial production of alginates

Cellulose Products of India Ltd., Ahmedabad have undertaken the industrial production of alginic acid and Sodium alginates. Their demand is about 700 tons of dried *Sargassum* per annum. They have plan for expansion in near future and then the demand will be doubled. At present their demand for *Sargassum* is met by the harvest on the southern coast. How far the supply of *Sargassum* will not be a limiting factor is not yet known. They claim 8–10 % yield of alginates from the sea weeds. Thus there is an output of about 60 to 70 tons of sodium alginate per annum. The market prize of sodium alginate is Rs. 35/- kg. including taxes.

Uses of Sodium alginate are not yet popularized in our country. A few industries at present are making use of alginates in their products.

Suggestions for future research work

(*a*) The foregoing survey of work done in this country on agar agar

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and algin reveals that the entire problem can be divided in the [following aspects :

1. A standardized survey of algal biomass including their ecology and life forms.
2. Physiology of algin and agar agar yielding sea weeds.
3. Standardization of extraction method.
4. Maricultures.
5. Training of scientists and technicians.

A few suggestions have been made on each of the above topics and it is upto the scientists of various specializations of formulate a research project on each of the above subjects. However, all such projects should be co-ordinated to avoid duplications.

Suggestions on survey research

1. A committee consisting of marine algologists, field ecologists, statisticians and scientists of related disciplines should standardize method of survey and prepare a proforma of procedure to carry out drift survey and determine litoral and deep water standing biomass of sea weeds.
2. Standing biomass of a given area should be estimated periodically. Subrahmaniam (1965) have made suggestions to assess sea weed resources. They are worth considering while estimating sea weed resources of an area.
3. Some agarophytes are dioecious, some have different stages in the life histories, such as Tetrasporophytes, Gametophytes, etc. The data should indicate the density of the above stages also. This might throw light on survival of these forms. It will also help in mariculture experiments.
4. Standard ecological methods such as permanent quadrats, clip quadrats and belt transects should be used depending upon the type of coast.
5. Growth data of certain economically important algal plants should be obtained. This is necessary because many red and brown algae do not regenerate within a year's time. Some of them take 2 to 4 years for reaching harvestable size. This fact would certainly affect the results calculated for harvest per annum.
6. Report from the Ministry of Commerce (F. p. 3 CSMCRI report) indicates that 220 tons of dry *Gelidiella* is exported annually. More than 100 tons of *Gelidium* was exported to USA (Desai, 1965). This export is a great drain on our algal resources. Government should formulate a policy for the export of sea weeds.

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7. It is suggested that many African countries and other neighbouring countries might be interested to export their sea weeds to India. Even such possibilities should be surveyed and the agar and alginate industries should be fed with imported sea weeds if the indigenous sources and not quite sufficient.

8. Indian scientists may collaborate with scientists of neighbouring countries to estimate the sea weed resources of those countries. This may be undertaken at a much later stage.

9. It is suggested that for the efficient survey the Indian coast should be divided into following sectors : (1) Gulf of Kutch and Okha, (2) Porbander, Veraval and Mahuva Sector, (3) Cambay to Bombay, (4) Bombay to Karwar, (5) Southern sectors may be sub-divided into East and West, (6) Eastern coast including Chilka lake.

If the preliminary survey does not promise a good scope the near by sectors may be amalgamated. Each of the sectors should adopt standardized methods of survey all throughout the year.

Chemistry of sea weeds

Agarophytes and algin yielding sea weeds which are found in abundance may be analysed biochemically keeping in view the biological importance of analysis. Tracer technique adopt by Doshi and Rao (1968) for studying biosynthesis of phycocolloids should be extended. Agar agar and algin content of such sea weeds should be seasonally assessed and variations in them in the species growing in different localities should be studied.

Properties of agar agar and algin which are industrially deserved should be studied with utmost care.

Extraction processes

A team of chemical technologists should evolve a standard procedure for the extraction of agar from sea weeds. This should include the study of best way of preservation of sea weeds during the transport from fields to factories.

Japan, Australia, USA and other countries have evolved the procedures for the extraction of agar and algin from sea weeds. These procedures cannot be applied to our country because of high temperature and other climatic conditions. Thivy (1961) has also suggested cottage industry method for agar extraction. A low temperature is needed to set the gel which cannot be brough about without the use of refrigeration in our climate. Thus there is a snag in practising agar cottage industry.

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Doshi and Rao (1967, 1968) have suggested that irradiation of sea weeds by Co–60, gamma-radiation enhance the gel strength and also helps in preservation of the sea weeds. KCl treatment only gives temporary effect and hence more work should be done on this line if economically and technically such a procedure is feasible.

In foregoing pages various methods of extraction of agar and algin have been summerized. Attempts have been made to evaluate the methods yet there is a scope for further research and chemical technologists can take up this problem taking all the factors including financial feasibility.

Mariculture (cultivation of sea weeds)

Natural resources alone may not be sufficient to feed the industries with sea weeds. They may be sufficient quantities in the beginning but they may get depleted by over harvesting. It is, therefore, necessary to plan out a well organised sea farming. Japan is well advanced in sea farming.

Prior to sea farming it is desirable to have studies on laboratory culture. CSMCRI have made a beginning in this direction. Many a time the behaviour of plants differ in laboratory and in fields. Therefore, it is suggested that most of the laboratory experiments must be carried out in light keeping in view the ecological conditions and there should be a number of replicates to varify the results statistically. Data obtained by monofactorial cultural studies which are usually carried out in the laboratories fail to give significant results when applied at field level. Therefore, one should guard oneself against the results of monofactorial cultural experiments.

It is felt that studies such as effect of hormones and substances like gibberellins on sea weeds are only of academic interest and perhaps not feasible financially at field level. Efforts should therefore, be concentrated on study of facts such as spore output, nature of substratum which promote the ecesis of sea weeds, action of tides and waves on growth and life histories of the algae and effect of such chemicals which take part in metabolic pools of algae.

Sea farming which is practised in Japan should also be practised here. A large strech of sea area may be based to private firms for cultivation.

Krishnamurthy (1965, 1967) have reviewed the prospects of sea farming. CSMCRI station at Mandapam has begun the cultivation of **Gracilaria** at Krusadi island. The crop ' ripeons ' within a period of five months. The harvest data, gel strength, variation in agar content and such other facts pertaining to products from cultivated crop should be determined.

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Sea weed pathology and parasitology are also developing branches. They will have to be studied at a later stage when sea farming is undertaken on larger scale.

Sea farming demands that the sea water should be comparatively calm, and unpoluted by industrial waste and silting should be minimum. These conditions are obtainable in gulfs and creeks. Some big lakes such as Nal lake in Gujarat which are near sea coast can be easily connected with sea and made suitable for cultivation of marine algae. How far this would affect water economy of the poeple living on the banks must be considered before.

Training in Marine Botany at Universities

Lastly it should be mentioned that national institutes and laboratories, and industries are fed by the product of universities. Thus the standard of research and technical development are already dependent upon the universiity education. If we desire to have well planned industries in marine products we should introduce a course of marine biology at post-graduate level. It is felt that there is no urgent need of starting a special institute to train post-graduate students in marine biology. Following suggestions are made to strengthen our education in Marine botany or Biology as whole :

1. There should be a special paper of Marine Botany at least in those universities which are situated in maritime states.
2. Such a course is planned by algal research committee held at CSMCRI, Bhavnagar.
3. The above course will be more forceful if a batch of students and teachers spend at least two months on sea shore and obtain a practical training in field collections, ecological studies and such other marine biological phenomena.
4. University or UGC may provide a special fund for the maintanence of above field study.
5. State fisheries departments which are well equipped with boats, other equipments and field staff may be requested to help such field groups.
6. A short term course can be arranged for unskilled and skilled workers who might be engaged in maintanence of sea farms, harvest and extraction.

Scope of sea weeds research in India

Research work related to sea weeds are carried out at (1) Central Salt and Marine Chemicals Research Institute, Bhavnagar, (2) Central Marine Fisheries

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Research Institute, Mandapam, (3) Central Fisheries Technological Institute, Tuticorin, (4) Madras University, (5) Poona University, (6) Gujarat University, (7) Andhra University. Now if a co-ordinated research programme is to be developed facilities, and personnels at above centres should be taken into consideration and their staff should meet to evolve a co-ordinated work.

Following suggestions are made :

(1) Central Salt and Marine Chemicals Research Institute, Bhavnager has a happy combination of Marine algologists, chemists, and technologists. The facilities at the Institute can be best exploited for Mariculture, sea farming, chemistry of agar, agarophytes, alginates and algiophytes, technology of extraction, improvement in quality of sea weed products. It is proposed that they may develop centre for sea farming at Okha.

(2) Centre at Gujarat University with collaboration with radiation chemistry division of CSMCRI, Bhavnagar may be assigned the work to study physiology of sea weeds. Dr. G. M. Joshi at Kolhapur University has done good deal of work on physiology of sea weeds especially Ulva. A centre may also be developed therefore southern sea coast.

(3) A survey team drawn from various institutes may survey the whole Indian coast for standing biomass of agarophytes and alginophytes. The details may then be worked out by regional centres.

(4) Taxonomic work may be undertaken by regional centres with the help of fisheries departments of the states :

(*a*) Madras University and Central Marine Fisheries Station at Mandapam in collaboration of other interested workers may survey the southern sea coast.

(*b*) Poona University may be a good centre for taxonomy of south-western coast.

(*c*) Gujarat University and C.S.M.C.R.I., Bhavnagar may study the algal flora of upper arabian sea coast.

Industries related to Agar agar and Alginate in India

A few private companies have started industrial production of Agar agar or alginates. They are as follows :

1. Sea Plants and Chemicals, 19, Boag Road, T-Nagar, Madras-1.
2. Indian Agar Pvt. Ltd. 61, Elliathporam Road, KOVILPATTY (Tirunewell Dist.).

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3. Indian Agar Company, Patan (N. Gujarat).
4. M/s Agar and Agarose Pvt. Ltd., Alleppy (S. India).
5. M/s Cellulose Products of India Ltd., Kathwada (Ahmeabad Dist.).

The above industries are hopeful about their prospects and they deserve every encouragement and technical advice.

A meeting of Biological Research Committee held on 10th and 11th July 1968 entrusted the senior author to prepar a note on Agar agar and Alginate resources of India. The present note is the outcome of the above decision.

One (B.S.V.) of us was granted financial assistance to visit varicus research centres in the country where the work on sea weeds are carried cut. Dr. Vaidya visited some of these centres and discussed the subject with the scientists and invited their suggestions. They are inccipciated in the present note. Industries engaged in the producticn cf Agar agar and alginates were also contacted personally or by communicaticn. Their views are also embodied in the note. Many scientific workers were contacted by post. Many of them sent their views which are included here.

We are grateful to the Chairman, C.S.I.R. for the travel grants to cne of us (B. S. Vaidya) and also to Gujarat University for peimitting to undertake this work. Our thanks are due to all those scientific wcikeis ard industrialists who gave their suggestions on the subject.

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UNSTEADY LAMINAR FLOW OF A VISCOELASTIC, ELECTROCONDUCTING FLUID UNDER THE ACTION OF A TRANSVERSE MAGNETIC FIELD

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1. Introduction :

The flow of a certain non-Newtonian fluid between two parallel plates under the action of a transverse magnetic field has been studied by Turgut Sarpkaya[1]. The corresponding steady flow for viscous Newtonian fluid has been discussed by Hartzmann and Lazarus[2], Cowling[3] and Ferraro and Plumpton[4]. Madan and Agrawal[5] has discussed similar steady flow of a viscoelastic fluid. We[6] have discussed in a previous paper the unsteady flow of an electroconducting liquid under the action of a transverse magnetic field. In viscoelastic fluids, we cannot neglect strain. Rivlin[7] and Reiner[8] have considered the relation between stress and rate of deformation. Stress has been assumed to depend on velocity gradient. More recently Rivlin and Ericksen[9] have shown that if we assume that in a viscoelastic fluid which is isotropic in its state of rest, the stress components are expressible as polynomials in gradients cf velocity, second acceleration, third acceleration........(n-1)th acceleration at any point considered, stress matrix $T=\| t_{ij} \|$ may be expressed as matrix polynomial in Kinematical matrices A_1, A_2.......A_n whose coefficients are expressible as polynomials in the traces of the products formed out of these matrices. Kinematic matrices are defined by the equation

$$A^r = \| A^r{}_{ij} \|$$
$$A^1{}_{ij} = V_{i,j} + V_{j,i} \qquad \ldots \quad (1)$$

$$A^{(r+1)}_{ij} = \frac{\partial}{\partial t} A^{(r)}_{ij} + V_l A^{(r)}_{ij,l} + A^{(r)}_{ml} V_{m,i} + A^{(r)}_{mj} V_{m,j} \qquad \ldots \quad (2)$$

In a latter paper Rivlin has considered simple types of steady state laminar flows.

In all these cases he took $A_r=0$ for $r>2$

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Taking $A_2 = B$; the general stress-strain relations can be given by

$$T = \phi_0 I + \phi_1 A + \phi_2 B + \phi_3 A^2 + \phi_4 B^2 + \phi_5 (AB + BA) + \phi_6 (A^2 B + AB^2) + \phi_7 (AB^2 + B^2 A) + \phi_8 (A^2 B^2 + B^2 A^2) \quad .. \quad (3)$$

and neglecting terms of third and higher order

$$t_j^{\,i} = \phi_0 \,\partial^i{}_j + \phi_1 A_j^i + \phi_2 B_j^i + \phi_3 A^i{}_\alpha A^\alpha{}_j \quad .. \quad (4)$$

Where the deformation tensor

$$A_{i,j} = V_{i,j} + V_{j,i} \quad .. \quad (5)$$

and the acceleration gradient tensor

$$B_{ij} = (a_{i,j} + a_{j,i} + 2V_{m,j} \; V^m{}_{,i}) \quad .. \quad (6)$$

Where V_i and a_i are the velocity and acceleration vectors respectively.

Though the coefficients ϕ_0, ϕ_1, ϕ_2 and ϕ_3 are in general functions of material invariants, we are restricting ourselves to the cases where they are constants. We will write $-\phi_0 = p =$ pressure; $\phi_1 = \rho\gamma$ where ρ is the density and γ the kinematic coefficient of viscosity. $\phi_2 = \rho e$ where e is kinematic coefficient of viscoelasticity and $\phi_3 = \rho\gamma e$ where γe is the coefficient of kinematical coefficient of crossviscosity.

Governing equations :

Neglecting displacement currents and free charges, the equations of hydromagnetic flows, for an incompressible viscoelastic fluid with constant electric and magnetic properties using rationalized MKS units (where Lorentz force is the only body force) are :

$$-e^{pqi} H_{p,q} = J^i \quad .. \quad (7)$$

$$e^{pqi} E_{p,q} = \mu_e \frac{\partial H^i}{\partial t} \quad .. \quad (8)$$

$$H^i{}_{,i} = 0 \quad .. \quad (9)$$

$$J^i = \sigma \left[E^i + \mu_e e^{pqi} V_p H_q \right] \quad .. \quad (10)$$

$$V^i{}_{,i} + 0 \quad .. \quad (11)$$

$$\rho \left(\frac{\partial V^i}{\partial t} + V^i{}_{,j} V^j \right) = t^{ij}{}_{,j} + \mu_e e^{pqi} J_p H_q \quad .. \quad (12)$$

$$\frac{\partial H^i}{\partial t} = -e^{rsi} \left(e_{pqr} \; V^p H^q \right) + \frac{\lambda}{\sqrt{|g|}} \left[|\sqrt{g}|\, g^{ik} H^i{}_{,k} \right], \quad \lambda = \frac{1}{\mu_e \sigma} \quad .. \quad (13)$$

$$\rho \left(\frac{\partial V^i}{\partial t} + V^i{}_{,j} V^j \right) = t^{ij}{}_{,j} - \frac{\mu e}{2} \left[\sum_j (H^i)^2 \right]_p g^{pi} + \mu_e H^i{}_{,j} H^j \quad .. (14)$$

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Where V^i = Velocity

H^i = Magnetic field intensity

E^i = Electric-field intensity

J^i = Current density

μ_e = Permeability of the fluid

σ = Electric conductivity of the fluid

λ = Magnetic diffusivity of the fluid.

Equations for Laminar flows :

We select a right-handed Cartesian co-ordinate system with x-axis along the direction of the flow through a fixed point on the plane equidistant from the bounding walls. Axis of Z is taken perpendicular to the walls. Let the equations of the walls be $Z = \pm L$. A uniform constant magnetic field Ho is applied in $0Z$ direction. Since the liquid near the plane $Z=0$ moves faster than near the walls, it tends to pull out the lines of force in the direction of the flow, giving rise to Hx, a component of the magnetic field parallel to the motion. We now have

$$\left.\begin{array}{l} V^1 = Vx, \quad V^2 = 0 \quad \text{and} \quad V^3 = 0 \\ H^1 = Hx, \quad H^2 = 0 \quad \text{and} \quad H^3 = Ho \end{array}\right] \quad \ldots (15)$$

$$\frac{\partial (Vx)}{\partial x} = 0 \quad \therefore \; Vx = Vx\ (z, t) \quad \ldots (16)$$

Similarly $H_x = H_x\ (z, t)$

The flow is symmetrical with respect to y-axis

hence
$$\left(\frac{\partial}{\partial y}\right) = 0$$

$$J^1 = J_x = \sigma E_x = 0\ ; \quad J^3 = \sigma E_z = J_z = 0 \quad \ldots (17)$$

$$J^2 = J_y = \frac{\partial (H_x)}{\partial z} = \sigma (E_y + \mu_e HoV_x) \quad \ldots (18)$$

Calculations :

$$(i) \quad A_{ij} = Vi,j + Vj,i = \frac{\partial V_i}{\partial x_j} + \frac{\partial V_j}{\partial x_i} \quad \ldots (19)$$

$$A_{ii} = 0 \;\therefore\; A_{11} = A_{22} = A_{33} = 0. \quad A_{12} = A_{21} = A_{23} = A_{32} = 0$$

$$A_{31} = \frac{\partial V_x}{\partial z} = A_{13} \quad \ldots (20)$$

$$A^1{}_3 = A_{3k} g^{ik} = A_{31}. \quad A_1{}^3 = A_{13}$$

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(*ii*) $Bij = a_i,\ j + a_j,\ i + 2Vm,\ i\ V^m,\ j$

$$= \frac{\partial^2 V_i}{\partial x_j \partial t} + \frac{\partial^2 V_j}{\partial x_i \partial t} + \frac{\partial V_p}{\partial x_j} \cdot \frac{\partial Vi}{\partial x_p} + \frac{\partial V_p}{\partial x_i} \cdot \frac{\partial V_j}{\partial x_p}$$

$$+ V_p \frac{\partial^2 V_i}{\partial x_j \partial x_p} + V_p \frac{\partial^2 V_j}{\partial x_i \partial x_p} + 2\ \frac{\partial V_m}{\partial x_i} + \frac{\partial V^m}{\partial x_j} \quad \ldots (21)$$

$$\therefore\ B_{11} = B_{22},\ B_{33} = 2\left(\frac{\partial V_x}{\partial z}\right)^2 B_{12} = B_{21} = B_{32} = B_{23} = 0.\ B_{13} = \frac{\partial^2 V_x}{\partial z \partial t}$$

$$B_3{}^1 = B_1{}^3 = \frac{\partial^2 V_x}{\partial z \partial t} \qquad B_3{}^3 = 2\left(\frac{\partial V_x}{\partial z}\right)^2 \quad \ldots (22)$$

$$(iii)\ t_x{}^x = -p + \rho \gamma_e \left(\frac{\partial V_x}{\partial z}\right)^2, t_y{}^y = -p;\ t_z{}^z = -p + \rho(2e + \gamma_e)\left(\frac{\partial V_x}{\partial z}\right)^2 \ldots (23)$$

$$t_z{}^x = t_x{}^z = \rho \gamma \left(\frac{\partial V_x}{\partial z}\right) + \rho e \frac{\partial^2 V_x}{\partial z \partial t} \quad \ldots (24)$$

$$t_y{}^x = t_x{}^y = 0. \quad \ldots (25)$$

Reduction of equations to simple forms :

$$\rho \frac{\partial V_x}{\partial t} = -\frac{\partial p}{\partial x} + \rho \gamma \frac{\partial^2 V_x}{\partial z^2}{}^x + \rho e \frac{\partial^3 V_x}{\partial z^2 \partial t} + \mu_e H_o \frac{\partial H_x}{\partial z} \quad \ldots (25)$$

$$\frac{\partial p}{\partial y} = 0;\ \frac{\partial p}{\partial z} + 2\rho\,(2e + \gamma_e)\frac{\partial V_x}{\partial z} \cdot \frac{\partial^2 V_x}{\partial z^2}{}^x = \frac{\mu_e}{2}\frac{\partial H_x{}^2}{\partial z^2} \quad \ldots (26)$$

$$\frac{\partial \mathrm{H}_x}{\partial t} = \mathrm{H}_0 \frac{\partial V_x}{\partial z} + \lambda \frac{\partial^2 \mathrm{H}_x}{\partial z^2} \quad \ldots (27)$$

$A,\ V_x$ and H_x are functions of z and t.

$\frac{\partial p}{\partial x}$ is independent of x and y.

There is a constant pressure gradient along the *direction of flow* at any particular instant.

Integrating (26), we get the pressure equation

$$p + \rho x + \frac{\mu_e}{2} H^2{}_x - \rho(2e + \gamma_e)\left(\frac{dV_x}{dz}\right)^2 = \text{constant.} \quad \ldots (28)$$

Conclusions :

(1) The velocity, when steady is not affected by crossviscosity or visco-elasticity but when unsteady a term $-\rho e \frac{\partial^3 V_x}{\partial z^2 \partial t}$ appears and there is some

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effect to reduce the velocity. The equation of velocity reduces to the same equation obtained by us[6] for non-elastic fluids by putting $e=0$.

(2) The magnetic component in direction of motion satisfies (27), the same equation as obtained by us[6].

(3) Pressure equation shows that the pressure fall along the direction of motion is constant.

It is not affected by the viscoelasticity or crossviscosity while pressure in the transverse direction is affected. The same conclusion is arrived at by Madan[5] for steady motion.

(4) Limiting forms of the flow :

By taking $e=0$, $\Upsilon_e=0$ the motion reduces to the Hydromagnetic motion of non-elastic electroconducting liquid and the results agree with those obtained before by us[6].

By taking the motion to be steady, the results are same as those obtained by Madan[5] for viscoelastic fluids.

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ON THE NORM OF AN OPERATOR

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If T is a bound linear transformation of a Hilbert space H into itself, then the norm of T is defined as

$$\| T \| = \sup_{\| x \| = 1} \| Tx \|, \; x \in H.$$

Now if H is a two-dimensional Hilbert space, then T has a metrix representation of the form $T = \begin{pmatrix} a+ib & c+id \\ p+ip & r+is \end{pmatrix}$ where a, b, c, d, etc. are real.

The aim of this short note is to obtain the value of $\| T \|$ in terms of a, b, c, d, etc.

The numerical range $W(T)$ of T is defined as the set of all complex numbers (Tx, x) where $\| x \| = 1$. Let $| W(T) | = \sup \{ z : z \in W(T) \}$.

Since $\| Tx \|^2 = (Tx, Tx) = (T^*Tx, x)$ { Here T^* is the adjoint of T and $T^* = \begin{pmatrix} a-ib & p-i \\ c-id & r-is \end{pmatrix}$ }, it follows that $\| T \|^2 = | W(T^*T) |$.

But T^*T being symmetric, $W(T^*T)$ is a line segment joining the eigen values of T^*T. Thus $| W(T^*T) | = \max \{ |\alpha|, |\beta| \}$ where α, β are eigen values of T^*T.

Now $T^*T = \begin{pmatrix} h & f+ik \\ f-ik & g \end{pmatrix}$

where $h = a^2+b^2+p^2+q^2$, $g = c^2+d^2+r^2+s^2$, $f = ac+bd+pr+qs$ and $k = ad - bc + ps - qr$.

The eigen values of T^*T are $\frac{1}{2} \{ h+g \pm \sqrt{(h+g)^2+4(f^2+k^2)} \}$. Since $\| T \| \geqslant 0$, $h \geqslant 0$, $g \geqslant 0$, it follows that $\| T \|^2 = \frac{1}{2} \{ h+g+\sqrt{(h-g)^2+4(f^2+k}$ where h, g, f and k are defined as above.

A particular case : If T is a unitary, then $T^*T = I$. Hence $h = g = 1$ and $f = k = 0$. Thus $\| T \|^2 = 1$ or $\| T \| = 1$ as we know.

Illustration : Let $T = \begin{pmatrix} 0 & 0 \\ 1 & 1 \end{pmatrix}$. Here $a=b=c=d=q=s=0$, $p=r=1$, i.e. $h=g=f=1$ and $k=0$. $\| T \|^2 = 2$ or $\| T \| = \sqrt{2}$.

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SYNTHETIC USE OF (+) AMYL BROMIDE FROM FUSEL OIL

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The fusel oil contains one of the constituents (–) amyl alcohol [(–) – 2 – methyl butan – 1 – ol, b.p. 126—128°, α_D^{32} – 1.109 (1=2)], which on bromination with red phosphorus and liquid bromine forms (+) amyl bromide [(+) – 2 – methyl 1 – bromobutane, b.p. 116–118°, α_D^{32} +0.263 (1=2)]. This optically active amyl bromide is used synthetically in the following reactions :

(1) The optically active amyl bromide reacts with ethyl acetoacetate in presence of sodium ethoxide and ethyl alcohol to form ethyl (+) amyl acetoacetate [b.p. 160–180°/20 mm. α_D^{30}+0.596 (1=2)], which on condensation with different aromatic amines to yield a carbamide derivatives and an optically active methyl hexyl ketone [b.p. 162—170°, α_D^{30}+0.185 (1=2)].

(2) The Grignard complex prepared from (+) amyl bromide reacts with various methyl ketones to yield optically active tertiary alcohols containing active amyl group. These alcohols are of the type R.CH_3. (+)C_5H_{11}. C – OH, where R=methyl, ethyl, n–propyl, n–butyl, n–amyl and n–hexyl. The optical rotation of these alcohols have been studied.

Experimental

(1) *Carbamides* : Ethyl (+) amy lacetoacetate and aromatic primary amines heated to boiling temperature to yield (+) methyl hexyl ketone and

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s-diaryl ureas. The following Table I shows the physical data of the carbamides :

TABLE I

No.	Carbamide	Yield %	M.P. °C	Nitrogen Found %	Nitrogen Calc. %
1.	*s*-Diphenyl carbamide	20	234	13.0	13.20
2.	*s*-Di-*o*-tolyl carbamide	18	245	11.4	11.60
3.	*s*-Di-*m*-tolyl carbamide	21	218	11.5	11.60
4.	*s*-Di-*p*-tolyl carbamide	21	261-2	11.5	11.60
5.	*s*-Di-*o*-chlorophenyl carbamide	12	237	9.8	9.96
6.	*s*-Di-*m*-chlorophenyl oarbamide	14	243	9.7	9.96
7.	*s*-Di-*p*-chlorophenyl carbamide	13	>288	10.0	9.96

(2) *Tertiary alcohols :* The Grignard reagent prepared as usual from magnesium (24.3 g., 1 mole), (+) amyl bromide (151 g., 1 mole) and dry ether (500 ml.). It was cooled below 10° and 1 mole of methyl ketone was added dropwise. Next day the reaction mixture was decomposed with ice and ammonium chloride. The crude tertiary alcohol was distilled under reduced pressure. The following Table II shows the physical data of these optically active tertiary alcohols :

TABLE II

No.	Tertiary alcohol	Yield %	B. P. °C/20 mm	d_4^{28}	n^{30}	α_D^{28}
1.	2:4-Dimethyl hexan-2-ol	48.5	56-70	0.8065	1.420	+0.422
2.	3:5-Dimethyl heptan-3-ol	59.0	70-82	0.8213	1.426	+0.262
3.	4:6-Dimethyl octan-4-ol	41.7	95-103	0.8258	1.431	+0.199
4.	5:7-Dimethyl nonan-5-ol	45.0	118-25	0.8264	1.435	+0.157
5.	6:8-Dimethyl decan-6-ol	53.5	143-55	0.8270	1.438	+0.139
6.	7:9-Dimethyl undecan-7-ol	32.6	160-70	0.8272	1.440	+0.127

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NEW SYSTEMATICS : A DYNAMIC APPROACH TO CLASSIFICATION OF PLANTS

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The problem of resolving world diversity of plant forms into a tangible and comprehensive system has agitated the minds of systematists from the earliest times. Vavilov (1922, 1940) was of the opinion that "the greatest problem of systematists is to build up a general well sustained monotypical system, where similarity and homological series of variation would be considered as the fundamental basis instead of an indefinite tangle of names impossible to remember".

The impact of plant physiology and biochemistry on the solution of taxonomical problems has been little in comparison to that of morphology and other descriptive branches of botanical science. Nevertheless the potentialities of comparative studies based on biochemical composition of individuals at different levels of taxa in establishing phylogenetic relationships are immense. Although the criteria obtained from comparative biochemical approach may not in itself form a basis for a convenient system of classification, they could make significant contributions in areas where morphological evidence alone is too indistinct to decide on the affinities between taxa or within a particular taxon. Rama Das (1962) has suggested that biochemical techniques should be used in addition to the conventional methods in the study of taxonomy.

Plant biochemistry is being extensively used these days in order to provide basis for classification and establishment of evolutionary relationship among species, genera and family, etc. In a number of cases even the ancestry of all tetraploids has been determined or confirmed on the basis of biochemical criteria (Smith and Levin, 1963; Stebbins et al, 1963). The extensive literature on this subject may be classified as follows :

1. Pigments; Anthocyanin; flavonoids; and alkaloids etc., as the basis for classification :

Fahselt and Ownbey (1968) have examined 10 species of **Dicentra** for flavonoid components including anthocyanins. These compounds formed

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definite patterns which were specific to a species or a group of closely related species, and confirmed certain natural relationships within the genus.

Manske and Holmes (1952) have reviewed the alkaloids in *Dicentra* and are of the opinion that every species investigated had a particular complement of alkaloids which distinguished it from the others, but there was more similarity of constituents among species, which were closely related taxonomically than among those more distant.

Roberts (1958) using paper chromatographic methods studied a number of species belonging to the section *Thea* of the genus *Camellia*. Here again phenolic substances such as depsides, flavonols and leucoanthocyanins were examined in the different varieties of classical tea plant, *Camellia sinensis* and between species of *Thea* group as well as the other sections of the genus. They found that the triglycosides of quercetin and kaempferol and an uncharacterised substance which they named as IC were of considerable taxonomic interest. Important differences between varieties were seen in these compounds. Large amounts of triglycosides are characteristic of China variety. The pattern of triglycosides in tea plant, which has mixed features of the varieties, closely agree with texonomical conclusions arrived through morphological studies. The chemical investigation of tea plants, provided a useful support for the taxonomist. Species within the section of *Thea* has close similarity in chemical characteristics.

The relationship of Hamamelidaceae to the family in Rosales and also to amentiferous families was investigated by Shaw and Gibbs (1961). A number of chemical characters such as leucoanthocyanin test, hydrogen cyanide test and presence and absence of glucitol and sedopetulose were used. The authors have assumed that those families which show close correspondence in chemical criteria are most closely related. 14 families belonging to Rosales were tried and on application of the above criteria, Shaw and Gibbs were of the opinion that an order Hamamelidales may be proposed to include Hamamelidaceae, Platanaceae, Myrothamnaceae and probably Cunoniaceae. Rosaceae will form a homogeneous group characterised by occurrence of glucitol and cyanogenetic glucosides, if the subfamily Chrysolidansideae is excluded. According to the chemical evidence Hamamelidaceae and Rosaceae strongly differ which sufficiently warrants their inclusion in separate orders. Similarly the authors found that if Garryaceae, Leitneriaceae and Juglandaceae were to be excluded, amentiferous families would form a natural group.

Bete-Smith (1962) has made quite an extensive study of the phenolic constituents present in the leaves of plant of dicotyledonous families. A chromatographic survey of leucoanthocyanins, flavonols, hydroxycynnamic acids and their substitution derivatives was made; leucodelphinidin, leucocyanidin,

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myricetin, quercetin, kaempferol, allagic acid, caffeic acid and p-coumaric acid were found to be the 8 commoner phenolic constituents of plants and all the rest of the compounds of phenolic nature being derived form them by various substitution reactions. It was assumed that the greater divergence in the structure of phenolics from the common constituents, the more likely they are to be of value as indices of affinity between species in which they are formed. Families that are positive to leucoanthocyanin and trihydroxy substituted derivatives are expected to be closely related than to those that are negative. Leguminosae alone among the families of dicotyledons contain all the classes of phenolic constituents.

Leguminosae has affinities with a large number of families and this agrees with the notion that Rosales occupy a central position in dicotyledons. The author found that Rosales, Parietales, Myrtales and Ericales to Ebenales have families in which leucoanthocyanin and trihydroxy substituted derivatives are concentrated. Subsidiary constituents are found to be more useful in establishing relationship within the family and the genus rather than at higher levels of taxa.

Phenolic constituents : During recent years the secondary phenolic constituents of species and hybrids in several plants and genera have been studied by paper chromatography. *Baptisia* was the first genus to be investigated by Alston and Turner (1959, 1962, 1963; Turner and Alston, 1959). This study was followed in *Asplenium* by Smith and Levin (1963) in *Lotus* by Harney and Grant (1963, 1964), in Collinsia by Garher and Stropmnaes (1964), in Zinnia by Torres and Legin (1964), in Tragopogon by Brehm and Ownbey (1965), in Phlox by Levin (1966) and others.

Resins : Ambers (resins) also can be basis for indicating relationships between genera (Langenhein, 1969). By means of infra-red spectrophotometry ambers have been analysed. Amber samples from different ages and locations give characteristic spectral analysis. For the non-volatile diterpene fractions of the taxa thus far investigated, differentiation of the genera is usually clear. Spectra of genera in the Taxodiaceae demonstrate a certain chemical heterogeneity. *Sequoia* and various spp. of Taxodium are distinct from *Metasequoia* and *Sequoiadendron* whose spectra are relatively similar.

Amongst the Angiosperms 3 genera of the Burseraceae : *Bursera, Protium and Canarium* are clearly distinguished. In the leguminosae resins of the African genera *Daniella* and *Copaifera* are distinguishable from the new world *Hymenaea* which however is similar to the African *Trachybolium* representative of genera in the Styraceae. Rutaceae, Anacardiaceae, Hamamelidaceae, *Zygo*phyllaceae and others give characteristically different spectral patterns.

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Organic acids : The usefulness of accumulation of an organic acid, tartaric acid as a taxonomic characteristic was examined in the family Geraniaceae by Stafford (1961). *Erodium* and *Geranium* were found to be non-accumulators of tartaric acid while majority of species of *Pelargonium* are high accumulators. A few species of *Pelargonium* are, however, low in tartaric acid while majority of species of *Pelargonium* are high accumulators. Stafford concludes that since there is need for improving the existing classification of Geraniaceae the criterion of tartarate accumulation may be used in addition to the characteristics.

Carbohydrates : Studies of chemical composition at intergeneric and intertribal level were carried out by Maclead and McCorquodele (1966). These authors have made determinations of water soluble carbohydrates including sugars, oligosaccharides and water soluble polysaccharides in the seeds of 22 species of Gramineae. The species selected were of different genera representing 11 tribes of the family. Their study showed that 2 tribes Bromeae and Hordeceae are uniquely characterised by the type of sugars formed in their seeds, the former containing fructosans but lacking raffinose and the latter containing fructosans as well as raffinose. It is possible to distinguish the species belonging to these tribes from the rest of grasses by their sugar content. They form natural tribes. It is suspected whether the former genera should be included in Avenae. On the other hand they show affinities to Agrostideae and Phalaris. The investigations of Macleod and McCorquodele clearly showed that biochemical criteria could form a powerful tool in establishing affinities. A comparative study of intermediary carbohydrate metabolism in acetic acid bacteria as a tool for interpretation of phylogenetic relationships was made by De Ley (1961).

Amino acids : Fowden and Steward (1957) studied 56 genera belonging to Liliaceae for nitrogenous compounds. Free amino acids identified and unidentified were compared for different genera. Some attempts for taxonomical correlation were made and in their opinion the ability to synthesize or accumulate certain compounds occurs widely throughout plants and the factors governing their distribution do not operate at genetic or specific level.

Similar results are reported by Vaidya (1962) for amino acids for Charophytes.

Proteins, Enzymes : Hart and Bhatia (1967) have worked out the soluble leaf proteins and enzymes from Nicotiana species using acrylamide gel electrophoresis. On the basis of their work they report that leaf tissue is not an ideal material for interspecies comparisons. In those tissues, in which the

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precise stage of development is not easily defined, it is necessary to insure that comparisons are made between identical ontogenetic stages so that inter-line similarities or dissimilarities are not marked by intraline variability. They further conclude that in the genus *Nicotiana*, interspecific differences in enzymes appear to be of significant magnitude that each species presented in this paper do not elucidate evolutionary relationships among the six species investigated. They do provide basic information for further work toward a molecular approach to taxonomic and evolutionary problems in higher plants.

Bhatia (1967) has considered a molecular approach to the phylogeny of wheat. The enzymes, esterases, peroxidases, alcohol dehydrogenase, and leucine amino peptidase occur in multiple molecular forms. It is very likely that most, if not all other enzymes also occur in different molecular forms. Functionally similar, though not structurally identical enzymes is made of one or more polypeptide chains and on the basis of our present knowledge of protein synthesis we can say that the primary structure of each polypeptide chain is determined by the nucleotide sequence of the DNA in the structural gene. For any specific enzyme, this information should be highly redundant in hexaploid species being contributed from three parental genomes. The results. indicate that bread wheat varieties of very diverse origin show a fairly uniform pattern with respect to the specific enzymes studied, though a few genetic variants were also observed. The enzyme heterogeneity is much greater between the species and between species of different ploidy. The present molecular forms in the hexaploid species must have evolved from the original forms contributed by the parental species.

By further chemical characterization of the molecular homologies of a specific enzyme in hexaploid, tetraploid and diploid species, probable genome donors, their hybrids and the synthesized polyploids it should be possible to infer evolutionary relationships and to trace back the evolutionary pattern of the genetic loci controlling these enzymes. Further on the basis of this information, some of the molecular alterations in the DNA contributed by each of the genome donors can be inferred. This considered in conjuction with the available morphological and cytological evidence will help in elucidating evolutionary relationships. Bhatia (1967–68) also studied the molecular forms of esterases (E.C.3.1) and alcohol dehydrogenase (E.C. 1.1.1.1.) separated by disc electrophoresis of Triticinae, to establish genome affinities within Triticinae, based on similarities of variation in analogous enzymes and to compare the results so obtained with those based on cytogenetic and morphological evidences.

Similarly proteins were examined for the organ as well as taxon specificity for several species belonging to the family Viciaceae by Klotz et al,

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(1960) using serological methods. Results obtained by them showed that protein characters were specific for each organ while species specificity being preserved.

In micro-organisms, particularly in respect of bacteria a number of physiological characteristics such as oxidase reaction have exclusively been used for taxonomical classification. Steel (1961) has made a thorough study of large number of strains of different families. The production of indophenol due to oxidation of dimethyl-p-phenylenediamine and α-napthol was used as a critical test. It shows the presence of cytochrome oxidase.

Rate of growth, catalase activity and nicotinic acid production were taken into account in classifying mycobacteria by Gillag (1961).

Studies similar to those on micro-organisms are lacking for higher plants. The distribution of terminal oxidases such as ascorbic acid oxidase among different plants if investigated on a large scale may prove very important for establishing affinities. Although cytochrome oxidase appears to be ubiquitous in its occurrence in systems. For instance, ascorbic oxidase is commonly present in members of Cucurbitaceae, similarly variations in carbohydrate metabolism, capacity to accumulate one or the other metabolite which again depends on the relative rates of the enzymic composition can all be used for purposes of finding out the natural relations of difference among plants (Rama Das, 1962).

Nucleic acids : Upadhyay and Swaminathan (1963) have taken into consideration the DNA content for wheat following the suggestion of Rees (1963) that the data relating to the DNA content of nuclei may provide a further clue regarding parental composition of allopolyploid plants like durum and bread wheats. The DNA content of nucleic would undoubtedly provide additional information of great value in tracing the phylogeny of hybrids and polyploids. An extensive survey of the extent of variability in DNA content occurring within a group of related species would have to precede the use of DNA values for such a purpose. The presence of hetrochromatic segments may also influence DNA values (Lima-de-Faria, 1959; Nirula et al., 1961), although in wheat this may be a complicating factor (Pai et al., 1961; Bhaskaran and Swaminathan, 1960). The drawback for this work is that the coefficient of variance values are rather high similarly to those reported by Rees (1963). Thus this work will be only of some use when a higher order of precision in measurement is realized.

Smoke (1964) has suggested that mean guanine and cytosine (GC) percentage in the DNA reflects phylogenetic relationship amongst organisms. At present the GC percentages afford no predictive relationship and the

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empirical data reveal only one generalization; a wider range of GC percentages is found in virus and bacteria than in higher forms and the range appears to decrease with increasing evolutionary complexity as determined by other taxonomic criteria. But as the differences in base composition increase between organisms, the likelihood of genetic retardation decreases.

There are very few studies of plant DNA from taxonomic point of view. Storck (1966) has compared G C percentage among fungi. Dutta et at. (1969) and Richman et al. (1967) have extended these studies and coupled them with DNA hybridization measurements. Dutta et al. (1967) conclude that the range of GC percentage variation is greatest in bacterial types, next in fungi and least in higher plants, but the range was greater in dicotyledons than in the monocotyledons, and GC content tended to be higher in the latter.

It would appear that those substances which are relatively more dynamic in the metabolism of plants will offer a less taxonomic potential. This is evident from the work on comparative studies based on free amino acids and organic acids. On the other hand phenolics and surface lipids, hydrocarbon constituents, fluorescent compounds are expected to offer much greater potential in taxonomical investigations. From the foregoing it is clear that these biochemical studies offer subsidiary help in relation to taxonomy.

A method based on energy requirement of plants has been suggested by Chinoy (1967), an outline of which is presented below :

Work during the last 30 years has shown that the phenomenon of correlation is a general one in plants (for references see Chinoy, 1966, 1968). The results show that the photothermic quantum determined as a product of summation of mean temperature and total photoperiod increased with the length of the growth period (days from sowing to anthesis) of a variety and was constant for a variety grown under varying photoperiods. The photosensitivity of a variety increased under vernalization and the highest for early varieties and progressively decreased for late ones (varnalization quantum increasing with lateness).

On the basis of these studies of correlations an integrated system of classification of different varieties and species in terms of their requirement for photothermic energy has been evolved (Chinoy, 1964*a*, 1967) as follows :

The photothermic quantum (E) of a variety is the product of the photo quantum of the variety and its thermic quantum (T). The photo-quantum o a variety in its turn is a product of the mean diurnal photoperiod (F) and the vegetative period (F) of the variety; while the thermic quantum is the prod-

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uct of the mean daily temperature (t) and the vegetative period (F) of the variety.

It, therefore, follows that,

$$E = PT = ptF^2$$

and $\therefore \quad F = \sqrt{\frac{E}{pt}}.$

It would appear from the foregoing that if the photothermic quantum of a variety is known, the approximate length of the vegetative period of a variety can be worked out for any given environment from the above formula by knowing the mean daily temperature and the mean day length during its growing season. The vernalization quantum of a variety will have to be taken into account also. If the temperature at the beginning of the growing season is conclusive to rapid completion of the thermophase the vernalization quantum will be small and the photothermic quantum for control and vernalized plants will not materially vary because the light energy will be efficiently utilized by the plant for the completion of the developmental process and consequently the vegetative period will need no correction. If, on the other hand, a variety is grown in a range of temperature which retards the processes of the thermophase (e.g. by growing winter varieties in a warm climate) the vegetative period will be prolonged owing to the inefficient utilization of light energy by the unvernalized plant, and therefore a correction of its growth period will be necessary.

Once the vegetative period of a given variety is determined for any locality, its growth (in terms of tiller production, leaf number, etc.) can be determined from the regression equation based on an already established correlation. Some of the illustrative data are presented in Table 1.

These varieties can be classified in terms of their energy requirement thus.

For instance, variety N. P. 165 can be written as *Triticum aestivum*, 4.31 (0.24); variety Vaneum Yakub can be written as *Triticum vavilonaninum* 17.91 (2.75) and so on; where it is understood that the figures outside the parenthesis stands for the photothermic quantum of the variety and the figure in parenthesis is its vernalization quantum. From these constants the vegetative period of a variety can be calculated as shown above in any given environment, provided the mean photoperiod and mean temperature of the growing period are known. Further the growth behaviour of the variety can also be known as already stated, from the appropriate regression equation.

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Table showing the relationship between growth vegetative period and photothermic as well as vernalization quanta

Genus	*Species*	*Variety*	*Vegetative period (days)*	*Photothermic quantum (E)*	*Verna-lization quantum (V)*	*Maxi-mum Tiller No.*	*Period of stem initiation (days)*	*Total leaf No.*
1	2	3	4	5	6	7	8	9
Triticum	aestivum	N. P. 165	77.3	4.31	0.24	7	50	50
T.	,,	N. P. 52	79.5	4.55	0.38	8	51	53
T.	,,	Cadia	82.8	4.95	0.50	8	56	55
T.	,,	Punjab CA591	84.0	5.07	0.62	9	57	60
T.	,,	Punjab 8–A	90.2	5.87	1.06	11	61	82
T.	,,	Union	96.0	6.67	1.38	13	64	105
T.	dicoccum	Khapli	101.3	7.21	1.06	14	75	132
T.	aestivum	Carlisle	102.0	7.58	2.26	14	77	140
T.	,,	Buhi	111.2	8.88	1.36	16	83	185
T.	durum	Mindum	123.7	11.28	1.72	22	94	293
T.	,,	Kubanka	125.6	11.69	2.51	24	95	350
T.	aestivum	Acme	129.5	12.54	1.62	29	100	410
T.	persicum	Persian Black	129.4	12.54	1.96	30	101	442
T.	aestivum	Amantaka	130.3	12.72	1.72	32	105	552
T.	polonicum	Polishwheat	137.1	14.41	2.24	38	112	685
T.	aestivum	Vaneum Yeoma	148.2	17.32	2.22	46	121	845
T.	vavilovianum	Veneum Yakub	151.2	17.91	2.75	50	125	915
T.	turgidum	Cambridge Rivett	152.9	18.78	3.94	53	123	1075

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It is possible to have broad classes having a definite class value for the photothermic quantum such as 4, 5, 6, 7, etc. and similarly for the vernalization quantum.

From the foregoing it is clear that a study of biochemical characteristics from random samples of plants belonging to related species, genera, and families is not likely to advance our knowledge of systematics to any appreciable degree unless and until an attempt is made to unravel its role in the metabolism of related plants in relation to their growth, development and energy requirement.

Therefore, the most important launching pad for a viable and integrated system of classification of the future will be the establishment of correlations between important physiological processes like growth, development, nutrition and regulatory mechanism of plants belonging to different varieties, species, genera and families in relation to their energy requirement for some of the processes.

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ASSESSMENT OF MICRONUTRIENT AVAILABILITY IN SOILS OF GUJARAT

Part I

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Introduction

Recognition of the role of trace elements in plant growth forms an important milestone in plant nutrition and it has paved the way for better understanding of the many mysteries in the behaviour of plants.

In India, uptil now micronutrients did not receive much attention for various reasons. In the past, organic manures, which are good sources for micronutrients were used in large amounts and use of high-analysis fertilizers was very much restricted. Besides the restricted use of high-analysis fertilizers there were many other reasons for the late introduction of micronutrients in Indian agriculture. The yields were low and the management practices were traditional. Recent introduction of high-yielding crop varieties responsive to fertilizers and most of the cultivated soils in India being of recent alluvial origin were not so much depleted of micronutrients as many highly leached soils of humid regions.

Realising the importance of establishing the micronutrient status of soil, the present study was taken up to assess the micronutrient status of soils of Baroda and Kaira districts of Gujarat State and delineate the deficiency areas falling under this common agro-climatic zone.

Material and methods

One hundred and nine representative soil samples from villages of Anand, Borsad, Petlad, Nadiad, Mehmadabad, Thasra, Kapadwanj and Balasinor talukas of Kaira district and Baroda, Savli, Waghodiya and Padra talukas of Baroda district were collected. These soil samples were analysed for the availability of different micronutrients. Iron by ortho-phenanthroline method using 1N NH_4OAc at pH 4.8 (Olson and Carlson, 1950), Mn by periodate method (Willard and Greathouse, 1917) using neutral 1N NH_4OAc with and without 0.2% hydroquinone as extractant, Zn by Holmes (1945) method using dithiazone-ammonium acetate as an extractant (Shaw and Dean, 1952), B by Hatcher and Wilcox (1950) methcd using hot-water as

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an extractant, Cu by improved carbamate method of Cheng and Bray (1953) using neutral normal NH_4OAc, and Mo by Grigg's (1953) method with slight modifications as suggested by Johnson and Arkley (1954) using acid ammonium oxalate at pH 3.3.

Results and discussion

Available iron content:

Iron extracted by 1N NH_4OAc at pH 4.8 is considered as available Fe in the present study. Talukawise distribution of available Fe in soils of both the districts together with the ranges of Fe content and their mean values are given in Table 1.

TABLE 1

Talukawise available iron content of soils of Kaira and Baroda districts

District	*Taluka*	*No. of sites*	*Available Fe (ppm)* *Range*	*Average*	*Sites having available Fe <2 ppm.*
Kaira	Anand	9	7.0 – 61.0	17.1	Nil
,,	Balasinor	7	4.7 – 29.7	13.9	,,
,,	Borsad	7	8.5 – 13.5	10.8	,,
,,	Kapadwanj	7	6.5 – 16.7	11.3	,,
,,	Mehmadabad	7	5.7 – 100.0	23.4	,,
,,	Nadiad	9	6.0 – 13.5	8.7	,,
,,	Petlad	10	6.7 – 21.2	12.3	,,
,,	Thasra	8	8.2 – 34.0	13.9	,,
Baroda	Baroda	5	6.2 – 23.0	14.2	Nil
,,	Padra	16	6.5 – 28.2	15.7	,,
,,	Savli	14	7.2 – 20.2	11.3	,,
,,	Waghodiya	10	7.5 – 39.5	13.9	,,

It ranged from 4.7 ppm in Pandava of Balasinor taluka in Kaira district to 100 ppm in Sinhuj of Mehmadabad taluka in Kaira district. The average value of Fe content in these soils was 13.8 ppm. Kanwar and Randhawa (1967), while reviewing micronutrient work in India, have mentioned that available Fe content in Indian soils varied between 0.5 ppm to 225 ppm. In studies of Fe chlorosis, Olson and Carlson (1950) found that

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1N NH_4OAc (pH 4.8) extracted from 0.01 to 0.3 ppm Fe from most soils, where Fe chlorosis was moderate to severe, 0.3 to 2.2 ppm where chlorosis was slight to moderate, and 2.0 to 32 ppm where chlorosis did not occur. Hence the limit for available Fe, below which Fe deficiency may develop, can be considered as 2.0 ppm. According to this standard, none of the soils may prove responsive to Fe application.

From the average values of soils of different talukas, it can be said that the minimum Fe content was observed in soils of Nadiad taluka, while maximum was found in soils of Mehmadabad followed by Anand taluka. The average Fe content of these two talukas increased considerably due to exceptionally high content of Fe in one village in each of these talukas. If village Samarkha in Anand taluka and Sinhuj in Mehmadabad taluka are not considered, then the average value of Fe content will dwindle down to 11.4 and 10.6 ppm respectively. Though the average available Fe content of Nadiad taluka was the least, the quantity available is sufficient to meet normal plant requirement. This is in agreement with the general observation made by Reddy and Mehta (1962) regarding the sufficiency of Fe in Gujarat soils.

Available manganese content :

Water-soluble and exchangeable forms of Mn are considered to be the most mobile forms and readily available sources of this element, but no separate estimation for them was done. They were determined together by shaking with normal ammonium acetate at pH 7.0 and called exchangeable Mn. Talukawise distribution of exchangeable and easily reducible Mn with their ranges and mean values for the soils collected from both the districts are given in Table 2.

It varied between 1.7 and 19.4 ppm with a mean value of 5.9 ppm for all the soils. Minimum exchangeable Mn was found in soils collectad from villages Asodar and Virsad of Borsad taluka and Dharmaj of Petlad taluka in Kaira district, and also in soils of Varnama of Baroda taluka and Vadu of Padra taluka in Baroda district. Maximum content was observed in soils of Raniya of Savli taluka in Baroda district.

Working with soyabean soils in Ohio, Hoff and Mederski (1958) found that Mn deficiency showed up when the values for Mn fell below 20 ppm on dry-soil basis. The satisfactory range was found to be 30 to 60 ppm Mn. The extractant used was ammonium dihydrogen phosphate. Sherman and Harmer (1943) have suggested 3 ppm exchangeable Mn as the critical limit below which deficient conditions may exist. Using magnesium nitrate as an extractant for exchangeable Mn, the limit set by Steenbjerg

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TABLE 2

Talukawise available manganese content of soils of Kaira and Baroda Districts

District	*Taluka*	*Sites having exch. Mn (ppm)* <3	*Exchangeable Mn in ppm* Range	: Av	*No. of sites having easily reducible Mn (ppm)* <100	>100	*Easily reducible Mn (including exch. Mn) in ppm* Range	: Av.	*Sites having exch. Mn < 3 ppm and easily reducible Mn < 100 ppm.*
Kaira	Anand	Nil	3.4–11.7	6.2	8	1	51.0–108.0	70.0	Nil
,,	Balasinor	,,	4.3–11.7	6.7	4	3	30.0–125.0	82.6	,,
,,	Borsad	Asodar Virsad	1.7– 9.5	3.9	7	—	35.0– 88.0	66.7	Asodar, Virsad
,,	Kapadwanj	Nil	3.0– 9.5	6.3	5	2	52.0–140.0	86.3	Nil
,,	Mehmadabad	,,	3.4–11.7	6.0	5	2	75.0–110.0	88.1	,,
,,	Nadiad	,,	4.0–10.6	7.6	9	—	42.0– 83.0	64.4	,,
,,	Petlad	Dharmaj Agas Bandhani	1.7– 7.6	4.2	9	1	35.0–145.0	62.1	Dharmaj, Agas Bandhani
,,	Thasra	Nil	3.4-12.2	7.7	8	—	50.0– 88.0	66.5	Nil

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Baroda	Baroda	Varnama	1.7- 6.2	4.0	1	4	56.0-140.0	116.0	Nil
		Itola							
,,	Padra	Vadu	1.7-12.2	5.0	15	1	49.0-113.0	72.4	Vadu
		Shanpur							
,,	Savli	Gandhi-apura	2.1-19.5	7.4	7	7	47.0-150.0	95.9	Nil
,,	Waghodiya	Limda	2.1-14.4	5.7	5	5	56.0-113.0	92.4	Nil

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(1935) for distinguishing healthy soil from deficient soils is 3 ppm of Mn in exchangeable form.

Taking into consideration the limit suggested by Sherman and Harmer, the soils of Asodar, Virsad, Dharmaj, Varnama, Vadu, Agas, Shanpur, Ganthiapura, Limda, Bandhani and Itola can be considered as those likely to respond to Mn application. In rest of the soils adequate supply of Mn can be obtained for the normal plant growth.

Besides exchangeable Mn as suggested by Sherman and Harmer, the fraction representing active manganese, i.e., exchangeable+easily reducible Mn brought into solution by 0.2 % hydroquinone in 1N NH_4OAc at pH 7.0 is often considered a reliable measure of plant available Mn. Easily reducible Mn content of soils collected form different villages ranged from 35 ppm in Dharmaj of Petlad taluka and Virsad of Borsad taluka in Kaira district to 150 ppm in Valavav of Savli taluka in Baroda district with a mean value of 79.2 ppm.

Sherman and Harmer (1943) reported that productive, neutral or alkaline soils usually contain 100 or more ppm of easily reducible Mn.

Considering easily reducible Mn content of those soils, which are evaluated as Mn-deficient soils on the basis of critical limit for the exchangeable Mn only, the soils collected from villages Varnama, Shanpur, Limda, Ganthiapura and Itola can be eliminated from the list of Mn-deficient soils as they contained more than 100 ppm of easily reducible Mn. Therefore, it seems that soils from Asodar, Virsad, Dharmaj, Vadu, Agas and Bandhani only may respond to Mn fertilization, eventhough Amin (1950) made a general observation regarding the sufficiency of Mn in Gujarat soils for normal and healthy crops and Mehta and Patel (1967) found sufficiency of readily available as well as reserve quantity of Mn in tobacco-growing soils of Kaira district.

Minimum average value of exchangeable Mn was 3.9 ppm for Borsad taluka and maximum was 7.7 ppm for Thasra taluka. Minimum average value for easily reducible Mn was 62.1 ppm for Petlad taluka and maximum 116.0 ppm for Baroda taluka. Talukawise distribution has shown that in Kaira district about 8 % of the soils contained less than 3 ppm of exchangeable Mn and these soils are in Borsad and Petlad talukas, while remaining 92 % soils contained adequate exchangeable Mn. In Baroda district about 13 % of soils contained less than 3 ppm exchangeable Mn and these sites are scattered in all the four talukas of Baroda district.

Easily reducible Mn content of 86 % of soils in Kaira district was less than 100 ppm, while in Baroda district it was less than 100 ppm in

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62% of soils. Although easily reducible Mn content of majority of soils was less than 100 ppm, but since they have fairly good amount of readily available Mn, plants grown on these soils do not suffer from Mn deficiency.

Available zinc content :

Talukawise distribution of available Zn content of soils of both the districts together with the ranges and their mean values are given in Table 3.

TABLE 3

Talukawise available zinc content of soils of Kaira and Baroda districts

District	Taluka	No. of sites	Available Zn (ppm) Range	Available Zn (ppm) Average	Sites having <0.5 ppm average Zn
Kaira	Anand	9	0.84-2.51	1.51	Nil
,,	Balasinor	7	0.85-6.70	1.97	,,
,,	Borsad	7	1.07-2.67	1.88	,,
,,	Kapadwanj	7	0.54-1.43	0.98	,,
,,	Mehmadabad	7	0.67-3.97	1.98	,,
,,	Nadiad	9	0.59-2.47	1.74	,,
,,	Petlad	10	0.85-2.70	1.43	,,
,,	Thasra	8	0.73-3.20	1.75	,,
Baroda	Baroda	5	1.22-1.75	1.42	Nil
,,	Padra	16	0.80-5.33	1.86	,,
,,	Savli	14	0.73-2.10	1.51	,,
,,	Waghodiya	10	0.55-2.65	1.18	,,

Dithizone-ammonium acetate-extractable Zn content of soils collected from parts of Baroda and Kaira districts ranged from 0.54 ppm in

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Torna soils of Kapadwanj taluka to 6.70 ppm in soils from Balasinor of Balasinor taluka both from Kaira district, with an average of 1.61 ppm for all the soils.

According to Berg (1947) the tentative limits for *Zn*-deficiency and *Zn*-toxicity in the case of available *Zn* (0.1N HCl-extractable) are below 1.0 ppm and above 100 ppm respectively. Tucker and Kurtz (1955) reported that there are chances for the occurrence of *Zn*-deficiency in the soils having less than 1 ppm of available (0.1N HCl-soluble) *Zn*. Bould *et al.* (1953) reported that soils containing less than 2 ppm available *Zn* determined by *Aspergillus niger* method, induced deficiency symptoms in fruit trees. Wear (1959) found no response of corn to *Zn* application on soils, of pH less than 5.9 or dithizone-extractable *Zn* of more than 0.9 ppm. Brown *et al* (1962) found that 84 % of the soils with 0.55 ppm ammonium acetate-dithizone-extractable *Zn* or less, responded to $ZnSO_4$ fertilization. In contrast 76 % of the soils containing more than 0.55 ppm failed to respond to *Zn* fertilization. They proposed 0.5 ppm as a tentative level below which a *Zn* response might reasonably be expected on sensitive crops.

In the present study, none of the soils contained less than 0.5 ppm of ammonium acetate-dithizone-extractable *Zn*. But the available *Zn* contents of soils from villages Torna, Karmasia and Sastapur were very near the critical limit of 0.5 ppm and may respond to *Zn* application particularly in the case of high-yielding varieties.

The minimum mean available *Zn* content of 0.98 ppm was observed for Kapadwanj taluka, while the maximum of 1.98 ppm in Mehmadabad taluka. Jayaram and Mehta (1967) found sufficiency of dithizone-ammonium acetate-extractable *Zn* in surface soils of the profiles collected from tobacco-growing villages of Kaira district.

Available boron content :

Hot-water soluble B content of soil is considered as available B. Its talukawise distribution in soils of both the districs together with the ranges and their mean values are given in Table 4.

It varied from 0.06 ppm in Tajpura soil of Padra taluka in Baroda district to 1.70 ppn in soil from Sinhuj of Mehmadabad taluka of Kaira district with an average of 0.35 ppm for all the soils.

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TABLE 4

Talukawise available boron content of soils of Kaira and Baroda districts

District	*Taluka*	*No. of sites having available B in ppm*			*Available B (ppm)*		*Sites having <0.1 ppm average B*
		<0.1	0.1–0.5	>0.5	*Range*	*Average*	
Kaira	Anand	2	7	–	0.08–0.33	0.24	Napad, Anand
,,	Balasinor	–	6	1	0.11–0.65	0.25	Nil
,,	Borsad	–	4	3	0.12–0.57	0.42	,,
,,	Kapadwanj	1	5	1	0.09–0.67	0.23	*Navagam*
,,	Mehmadabad	–	3	4	0.19–1.70	0.79	Nil
,,	Nadiad	–	3	6	0.13–0.89	0.54	,,
,,	Petlad	–	5	5	0.19–0.98	0.48	,,
,,	Thasra	–	7	1	0.10–0.85	0.28	,,
Baroda	Baroda	–	5	–	0.19–0.44	0.29	Nil
,,	Padra	1	12	3	0.06–1·00	0.38	Tajpura
,,	Savli	–	13	1	0.10–0.56	0.24	Nil
,,	Waghodiya	–	10	–	0.12–0.26	0.17	,,

In a survey of swede fields in Cumberland, Dermott and Trinder (1947) observed that, in general, the *B* content of fields showing "brown heart" was less than 6.3 ppm. Jordan and Powers (1946) suggested the following standrdas for deficient, optimum and excessive quantities of available *B* in soil :

(*a*) Less than 0.50 ppm ... deficient

(*b*) 0.50 to 0.75 ppm ... optimum

(*c*) more than 0.75 ppm ... excessive to toxic.

Stinson (1953) reported that 0.3 ppm was critical for alfalfa in sandy soils. Berger's (1949) standard for probable available *B* content of

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soil required for optimum growth for some common field and vegetable crops is as under :

(*a*) Plants with high *B* requirements more than 0.5 ppm
(*b*) Plants with medium B requirements 0.1 to 0.5 ppm
(*c*) Plants with low *B* requirements less than 0.1 ppm.

Though there are obvious differences in the standards suggested by different investigators, it appears safe to follow Berger's suggestion for the classification of the soils according to their available *B* contents. Based on this standard, soils of Baroda and Kaira districts can be divided into three groups as under :

Group number	*Range of available B (ppm)*	*Number of sites*
1	Below 0.1	4
2	0.1 to 0.5	80
3	more than 0.5	25

All the soils fall in groups 2 and 3 except the four soils, viz., Napad and Anand from Anand taluka and Navagam of Kapadwanj taluka in Kaira district and Tajpura in Padra taluka of Baroda district which fall in group 1 and are likely to respond to *B* application depending upon nature of the crop. Excluding these four soils there is sufficiency of *B* in soils of this region for crops of low and medium *B* requirement. Gandhi and Mehta (1958) made a general observation that available *B* contents of Gujarat soils were quite sufficient for the crops having low and medium *B* requirement.

Amongst different talukas, minimum average available *B* content 0.17 ppm was observed in Waghodiya taluka, while maximum 0.79 ppm was found in soils of Mehmadabad taluka. Talukawise distribution reveals that 62 % of the soils collected from Kaira district fall under group 2, 33 % fall in group 3 and 5 % in group 1. In Baroda district 89 % of soils come under the group 2, 9 % in group 3 and 2 % in group 1. Hence, there is an indication that on any of the soils except those from Napad, Anand, Navagam and Tajpura, the crops of low *B* requirement like wheat, oats, barley, corn, soyabeans, peas, beans, potato, grasses, flax, etc. and the crops of medium *B* requirement such as tobacco, tomato, lettuce, cotton, sweet potato, pea-nut, carrot, onion, etc. can be grown without addition of *B*. Similarly on sites falling under group 3, not only plants having low and medium *B* requirements but also those having high requirements such as alfalfa, clover, beets, turnips, cabbage, cauliflower, radish, etc. can be grown without *B* application.

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Available copper content :

Available Cu contents of soils collected from parts of Baroda and Kaira districts are given talukawise with their ranges and mean values in Table 5

TABLE 5

Talukawise available copper content of soils of Kaira and Baroda districts

District	*Taluka*	*No. of sites having available Cu in ppm*			*Available Cu (ppm)*		*Sites having <0.1 ppm of av. Cu.*
		<0.1	0.1–0.5	>0.5	*Range*	*Average*	
Kaira	Anand	–	9	–	0.10–0.36	0.17	Nil
,,	Balasinor	1	5	1	0.06–0.56	0.20	Gadhawada
,,	Borsad	1	6	–	0.06–0.41	0.20	Anklao
,,	Kapadwanj	3	4	–	0.06–0.11	0.09	Pithai, Porda, Torna
,,	Mehmadabad	1	5	1	0.09–0.65	0.20	Mankwa
,,	Nadiad	3	6	–	0.07–0.25	0.14	Dabhan, Uttarsanda, Sastapur
,,	Petlad	1	9	–	0.09–0.20	0.14	Sunav
,,	Thasra	3	5	–	0.06–0.22	0.12	Ambav, Kalsar, Nes
Baroda	Baroda	1	4	–	0.09–0.29	0.21	Ataladara
,,	Padra	1	13	2	0.09–1.00	0.26	Sanghama
,,	Savli	2	12	–	0.05–0.34	0.15	Raniya, Varasda
,,	Waghodiya	–	10	–	0.14–0.25	0.17	Nil

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It was found to vary from 0.05 ppm in Raniya of Savli taluka in Baroda district to 1.0 ppm in Latipura of Padra taluka of Baroda district.

Wood (1945), studying the Oregon soils for their Cu status, determined the available Cu by neutral normal ammonium acetate methcd and concluded that a supply of 0.1 to 1.0 ppm of exchangeable Cu in surface soil is sufficient for normal growth provided that this quantity is maintained and that a working margin of 0.5 ppm of Cu available to plant roots should indicate roughly the boundary between response and no response to Cu additions. The extraction procedure followed in the present investigation was the same as that followed by Wood (1945), and hence using the classification suggested by him, soils of Baroda and Kaira districts can be divided into three gourps as under:

Group	*Range of available Cu in ppm*	*Number of sites*
1	below 0.1 (deficient)	17
2	0.1 to 0.5 (moderately well supplied)	88
3	more than 0.5 (well supplied)	4

It can be seen that 17 soils fall in group 1 (Cu-deficient soils) and response may be expected on these soils to Cu application, while remaining soils under present conditions are capable of supplying sufficient Cu for the normal growth of plants. These Cu-deficient soils are lccated in villages Raniya, Anklao, Pithai, Gadhawada, Porda, Ambav, Varasda, Dabhan Kalsar, Nes, Torna, Uttarsanda, Sunav, Mankwa, Sastapur, Sanghama and Ataladara.

The average available Cu for the taluka varied from 0.09 ppm for Kapadwanj to 0.26 ppm for Padra taluka. In Anand and Waghodiya talukas there was not a single soil with available Cu less than 0.1 ppm. In the others were some soils having available Cu less than the critical value of 0.1 ppm as suggested by Wood.

Available molybdenum content :

Available Mo contens of soils talukawise with the ranges and their mean values are given in Table 6.

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TABLE 6

Talukawise available molybdenum content of soils of Kaira and Baroda districts

District	*Taluka*	*No. of sites having available Mo in ppm*		*Availbale Mo (ppm)*		*Sites having*
		<0.05	>0.05	*Range*	*Average*	<0.05 *of av. Mo*
Kaira	Anand	3	6	0.034–0.114	0.060	Samarkha, Navli, Jitodiya.
,,	Balasinor	3	4	0.034–0.098	0.065	Gadhawada, Balasinor, Vadadla
,,	Borsad	1	6	0.044–0.086	0.072	Virsad.
,,	Kapadwanj	7	–	0.021–0.047	0.037	Pithai, Chhipadi, Navagam, Nirmali's movadu, Lasunndra, Porda, Torna
,,	Mehmadabad	4	3	0.034–0.098	0.055	Mankwa, Khumarvad Khuntaj, Sinhuj.
,,	Nadiad	3	6	0.034–0.101	0.058	Chunel, Uttarsanda, Chaklasi.
,,	Petlad	2	8	0.034–0.090	0.060	Nar, Tarapur (Cambay).
,,	Thasra	2	6	0.030–0.072	0,054	Nes, Manjipura.
Baroda	Baroda	1	4	0.034–0.116	0.070	Itola
,,	Padra	2	14	0.024–0.125	0.075	Chansad, Sokhada-khurd
,,	Savli	7	7	0.027–0.105	0.055	Savli, Valavav, Varasda, Vejpur Ganthiapura, Devpura, Wankaner
,,	Waghodiya	2	8	0.027–0.090	0.061	Rampura, Raval

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The least available Mo content (0.021 ppm) was found in Torra soil, while highest (0.125 ppm) was in soils of Mobha and Rajupura. The overall mean value for Mo content was 0.06 ppm.

According to Grigg (1953), Mo extracted by acid ammonium oxalate (pH 3.3) measures available Mo in soil. The level below which field response is likely to occur is 0.05 ppm for practically neutral soils. Walsh et al. (1953) found that excess Mo in herbage was associated with acid ammonium-oxalate-extractable Mo levels as low as 0.8 ppm in soils of pH 5.0 and as low as 0.3 ppm in slightly acid to alkaline soils.

The pH of the soils of this tract is around neutrality or slightly on alkaline range. But in none of the soils, the value of available Mo exceeds the value of 0.3 ppm suggested by Walsh et al. (1953) for excess. On the basis of Grigg's standard for deficiency, 37 sites contained less than 0.05 ppm of Mo and are likely to respond to Mo application.

The mean available Mo content of soils of different talukas varied from 0.037 ppm in Kapadwanj to 0.075 ppm in Padra taluka. In Kaira district 25 sites amounting to about 39 % of the soils were having less than 0.05 ppm Mo and these sites are scattered throughout the district. All the soil samples collected from Kapadwanj taluka contained less available Mo than the critical value of 0.05 ppm. Similarly in Baroda district, amongst four talukas 27 % of the soils contained less than 0.05 ppm Mo of which maximum sites are form Savli taluka.

Thus, in general, the response to Fe application is not likely under present conditions on the soils of Kaira and Baroda districts. Molybdenum as well as Cu fertilization may have beneficial effects on some of the talukas of both the districts, and a probable response to Mn, *B* and *Zn* application may be obtained on few sites in some of the talukas of both the districts.

SUMMARY

This investigation was undertaken to assess the availability of Fe, Mn, Zn, B, Cu and Mo in the soils of Baroda and Kaira districts of Gujarat. It was found that none of the soils contained less than 2 ppm of Fe extracted by 1N NH_4OAc at pH 4.8, below which response to Fe application is likely indicating sufficiency of Fe in these soils.

According to the limits of 3 ppm for exchangeable Mn and 100 ppm for easily reducible Mn for productive, neutral and slightly alkaline soils, the soils from villages Asodar, Virsad, Dharmaj, Vadu, Agas and Bandhani can be considered Mn-deficient.

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Soils form Trona, Karmasia and Sastapur, which have their Zn-content near the critical limit of 0.5 ppm as determined by extraction with dithizone-ammonium acetate, can be considered Zn-deficient.

Soils of Napad, Anand, **Navaga** n and Tajpura contained less than 0.1 ppm of hot water-soluble B and can be considered B-deficient.

Available Cu content as determined by extraction with neutral normal ammonium acetate was below 0.1 ppm in 16 per cent of the soils. They are scattered throughout the area and crops grown in them may be benefitted by Cu fertilization.

Available Mo content of 35 per cent of soils extracted by acid ammonium oxalate at pH 3.3 was below the critical level of 0.05 ppm. All the soils from Kapadwanj taluka had their contents below the critical level.

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